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Transactions
Kansas Academy of Science

Volume 51, No. 1 — March, 1948

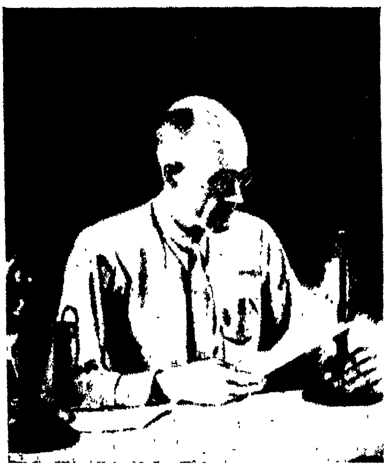
Kansas Weather: 1947

S. D. FLORA
U. S. Weather Bureau, Topeka.

As is our custom, we present in each March issue of the Transactions, *Mr. Flora's annual summary of Kansas weather for the preceding year. Mr. Flora, well-known to Kansans, has been associated with the Topeka office of the United States Weather Bureau for over forty years. He will soon publish a monograph on Kansas weather which will be awaited with considerable and real interest.*—The Editor.

General Summary

Weather conditions over Kansas during 1947 were almost ideal for wheat but decidedly unfavorable for corn and many other spring-seeded crops which had a late start because of cool wet weather during the spring and were badly damaged in a severe drought and hot spell that began the latter part of July and continued through September.



S. D. FLORA

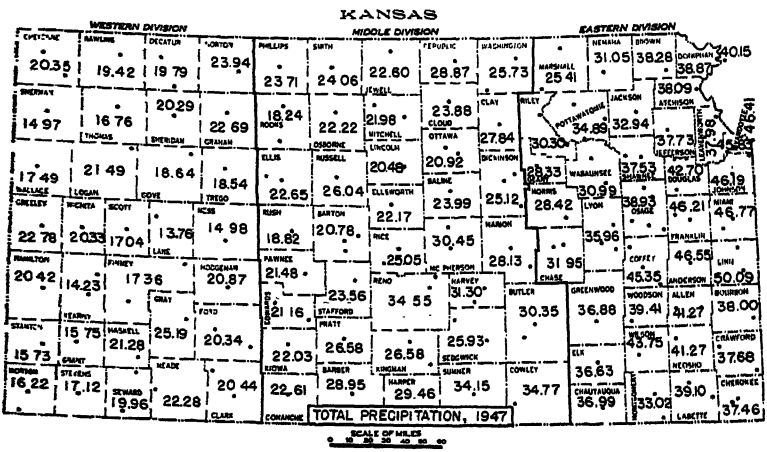
The average fall of moisture over the eastern third of the state was 37.60 inches; the middle third, 25.74 inches; the western third, 18.94 inches; and for the State as a whole, 27.43 inches, which was 0.48 inch above normal, six inches less than the average for 1946, and the second lowest average in seven years. The greatest total reported was 50.09 inches at LaCygne, Linn County, and the least was 13.76 inches at Healy, Lane County. Snowfall for the year was 50% above normal.

The mean temperature, 55.2°, was 0.2° above normal but the

year was marked by unusual extremes. On January 4 a low of 35° below zero was recorded at Centralia, Nemaha County, which has been exceeded in but one month, February 1905, since the state-wide record was begun 60 years ago. The highest for the year was 117° on September 3 at Lincoln, which was by 4° the highest September temperature of record and higher than any other temperature experienced in the State since the hot summer of 1936.

The year began with a January that was mild and pleasant after the first six days, followed by abnormally cool weather through the next five months that was fine for wheat but delayed spring work greatly, especially as wet weather prevailed through March, April, May, and June, with extensive overflows, some of which (in June) were among the greatest of record.

Rainfall was deficient in July and a hot spell began on the 26th that continued almost without a break for three months. August was the hottest month of the name in ten years and the driest in eleven years, while record-breaking or near record-breaking hot weather continued through September, with rainfall that was de-



Rainfall values are for individual stations in each county and are not county averages.

cidedly deficient. Pastures dried up and corn suffered further damage.

October was the warmest on record and below normal in precipitation, which resulted in a very unfavorable condition for seeding wheat. November, however, was cool and cloudy, with frequent light rains, and December falls of moisture totalled heavier than any that had occurred since June, which materially improved the prospect for the next year's wheat crop.

More detailed accounts of 1947 wind, hail, and ice storms and of floods, followed by summaries of weather conditions for individual months, are given below.

Windstorms

Tornadoes and windstorms of other nature were numerous but not especially destructive during the year. Severe hailstorms occurred with unusual frequency and hail damage reported was close to the highest of any year on record.

A total of 19 tornadoes was reported, which is three more than the 33-year annual average for the State. Total damage from these storms, most of which occurred in April, was $652,550. Several persons were injured but there was only one fatality, which occurred in Norton County on June 21.

The two most destructive tornadoes of the year occurred on the evening of April 9, and one of them, at least, was a continuation of the tornado which devastated Woodward, Oklahoma. This one crossed into Kansas just west of Hartner at 10 p.m. and traveled 40 miles before dissipating. It passed through Gerlane and the edge of Nashville, Kansas, and ended six miles north of the latter place at 11 p.m. Damage in Kansas was estimated at $200,000.

The other tornado, which caused damage estimated at $225,000, originated seven miles north of Meade at 5:30 p.m., passed within two miles of Fowler, and ended about ten miles southeast of Dodge City.

Forty-four violent windstorms that were not of tornadic nature were reported during the year, with estimated damage totaling $729,300. The most destructive of these swept a path diagonally across Sumner County on June 25 and was accompanied by heavy hail. Total damage from wind and hail was placed at $1,500,000, of which about $500,000 was due to wind losses that included damage to oil derricks and silos.

The second most destructive windstorm of the year occurred in Neosho County on June 7 and was accompanied by heavy hail. The total loss of the storm was placed at $175,000, of which about $100,000 was from wind. The chief damage was in and near Chanute.

Hail Damage

A total of 77 heavy falls of hail was reported with estimated damage amounting to $10,767,500, which has not been exceeded by hail damage reported to the Weather Bureau in any other year since 1928 and was almost three times the damage of 1946. Most of these

losses occurred in June, when the State had 35 hailstorms as wheat was approaching harvest, with losses totalling $7,278,500. There were hundreds of smaller losses, of course, that escaped the Weather Bureau's network of reporting stations.

Four hailstorms caused losses of a million dollars, or more, each. The most damaging group occurred in Kingman County on June 25 and 26, with losses totalling $2,250,000. Damaged areas were centered from Varner and Kingman eastward to the county line on the late afternoon of the 25th and from Calista to Adams on the early morning of the 26th. Another million-dollar loss occurred at about the same time in Sumner County over paths spreading southeast of Belle Plaine and centering south of Mayfield and Perth.

On June 5, north-central Cheyenne County was devastated by the worst hail storm that section had known for years. Losses, mostly to wheat, totalled $1,000,000.

The evening of May 27 a million-dollar hail loss occurred in Reno County from west of Nickerson to southeast of Haven, with spotted damage elsewhere in the county. Hailstones generally ranged up to an inch in diameter. One of the larger of these, near Partridge, struck a light switch on a barn, turning on the light.

Ice Storm Damage

The most destructive storm of the year was one of freezing rain and sleet on the late evening of December 2 and continuing until the afternoon of the 3rd. This storm covered much of the central part of the State and resulted in damages totalling $3,050,400. Power and communication lines were completely broken down in many places and severe damage was done to shade trees and ornamental shrubbery. Some cities were without electric lights and power for considerable periods ranging from a day to two weeks until lines could be rebuilt. Livestock suffered considerably but wheat was benefited by the added moisture.

Overflows of the Year

Overflows occurred during the year in every important river of the State except the Smoky Hill, with damages in Kansas, according to the best available estimates, totalling $11,901,448, most of which was to agricultural interests. There was no loss of life from floods in Kansas, though there were 13 lives lost in a flash flood in the Republican Basin at Cambridge, Nebraska.

The two outstanding overflows of the year occurred along the

Republican and Blue Rivers and ranked among the greatest known along those streams.

The Republican River overflow was largely due to torrential rains falling in Furnas and Harlan Counties, Nebraska, augmented materially by floods along Beaver and Sappa Creeks. It crossed the line into Kansas on June 22 and crested at Junction City on the 28th. Crest stages in Kansas closely approximated those of the great overflow of 1915 but were below those of 1935, the greatest flood of record along this stream. Damage in Kansas, according to the survey of the U. S. Reclamation Service, totalled $5,619,178, of which $4,934,925 was to agricultural interests. Damage in Nebraska, including a major disaster at Cambridge, totalled $10,323,338.

The only other overflow of the Republican was a slight one at Clay Center during April.

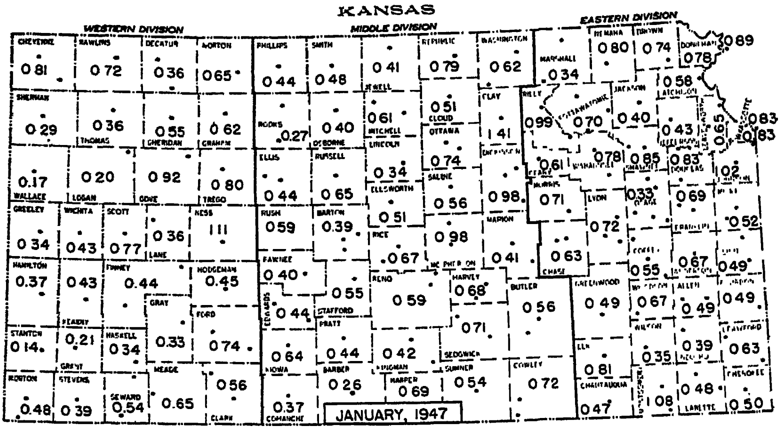
The Blue River overflowed slightly in April with a loss of $84,300.

The great overflow of the Blue was largely due to torrential rains in Nebraska. It crested at Beatrice, Nebraska, with a stage of 27.65 feet on June 23, which is very nearly a record-breaker for that point. At Barnston, Nebraska, a crest of 29.79 feet the same day has been exceeded only once, by 34.3 feet in June 1941. The Little Blue also staged a great overflow about the same time, with a crest of 20.2 feet at Hanover on the 24th, the highest of record at that place except possibly in 1903.

Crests below the junction of the Big and Little Blue have seldom been exceeded by overflows of record. At Blue Rapids the crest was 33.25 feet on the 24th and at Randolph, 27.03 feet on the 25th.

Several other overflows of less magnitude occurred along the Blue River in June. Total damage in the Blue Basin in Kansas during the year, most of which occurred in the great overflow of June, was estimated at $1,459,080, with $1,471,840 additional damage in Nebraska.

There were several overflows along the Marais des Cygnes (Osage) River. A moderate overflow occurred in March, with damage totalling $381,630, most of which was to flooded farm land. In April there were two overflows at Quenemo and Ottawa that extended to the Missouri line. At Trading Post the river was continuously above flood stage from April 5 to 19, with much crop damage. Losses from this overflow were estimated at $780,500. In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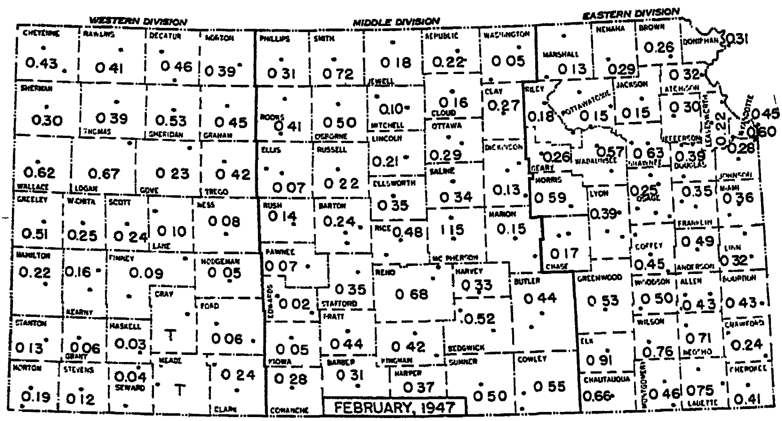
JANUARY, 1947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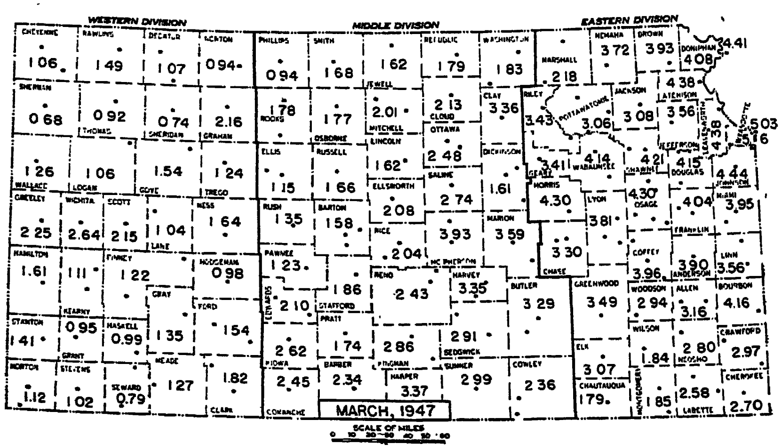
WESTERN DIVISION
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MARCH, 1947
SCALE OF MILES

June most points along this stream had two moderate overflows, with losses estimated at $729,200, making the total flood loss for the year in the basin in Kansas $1,891,330.

The Cottonwood and Neosho overflowed slightly in places in March and June and staged two or three rather bad overflows in April. Total damage in these basins was estimated at $72,000, most of which was in connection with the April floods.

The Verdigris, Walnut, Ninnescah and Chikaskia Rivers also overflowed in April, with damages estimated as follows: Verdigris, $89,000; Walnut, $63,000; Ninnescah and Chikaskia, $222,500.

The Arkansas overflowed moderately below Wichita in April and slightly at Great Bend in June, and the Little Arkansas overflower at Sedgwick in April. Damage from these overflows was slight.

The Kansas River overflowed slightly in April, except at Topeka, and moderately along its entire length in June. Damage in the basin of this river was estimated at $1,682,840, most of which occurred in the June flood and was largely to agricultural interests.

The Solomon River overflowed slightly in April, with damage estimated at $336,260. In June it overflowed moderately three times at Beloit, with damage in the basin estimated at $466,310. Practically all loss was to agricultural interests.

The Weather by Months

January—Mild and pleasant weather prevailed after the opening days of the month, which were unusually cold. Precipitation was less than usual. Afternoon temperatures ranged in the 50's and 60's on a large number of days after the 6th. Snowfall was heavier than usual and was well distributed over the State. Soil moisture continued ample, except in some southwestern counties, and wheat remained in excellent condition.

February—The coldest February weather since 1939 prevailed, with less precipitation than in any other February in 11 years. The three-month winter period which it completed was the driest in 11 years and the sixth driest winter the State had experienced in 60 years. Abnormally cold weather was continuous the last ten days of the month. It was favorable for outdoor work, and sowing oats

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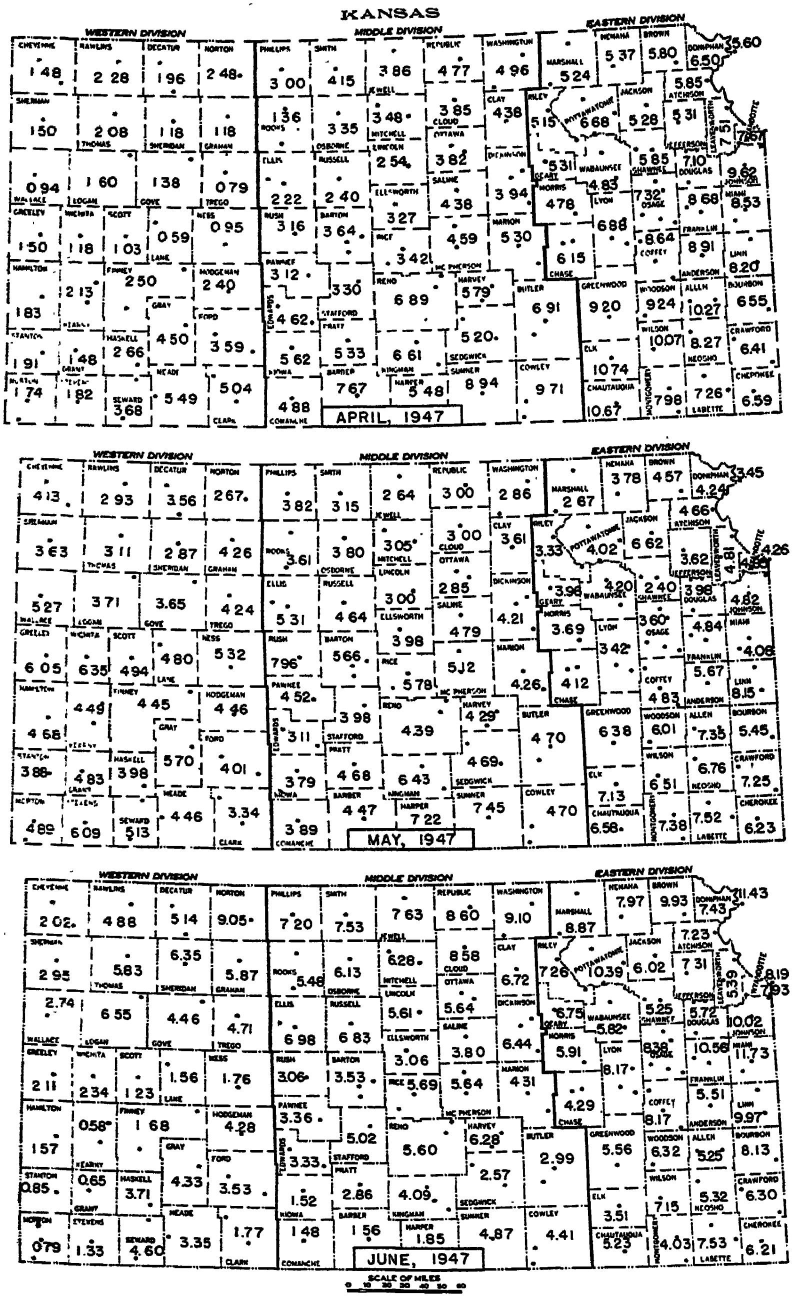
"T" indicates trace", i.e., less than 0.005 inches. Values given in each county are for individual stations.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JUNE, 1947
SCALE OF MILES
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was well advanced. Wheat came through in good condition but was needing more moisture.

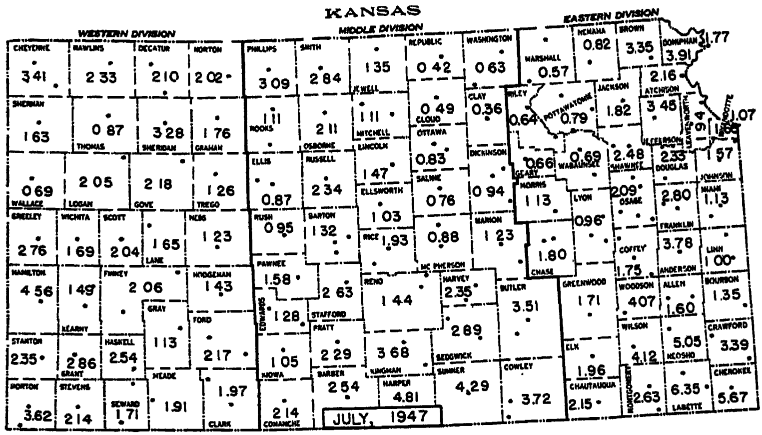
March—Unusually cold, cloudy, and wet weather prevailed and was fine for wheat but left farm work two weeks or more behind the season. Snows that fell during the month melted rapidly but totalled greater than those of any other month in two years. Wheat made little growth until near the close of the month. Sowing oats was held in abeyance until near the close and no potatoes were planted in commercial fields of the Kaw Valley by the 17th.

April—Cool, rainy, and cloudy weather delayed farm work, which was almost four weeks behind the season at the close. Conditions, however, were fine for wheat. It was the fifth wettest April on record and rainfall was 50% more frequent than usual. Wheat made an excellent growth and, by the close of the month, was jointing in most areas with some coming into the boot in the more southern counties. Very little corn was planted.

May—Cool, wet weather continued to delay farm operations but was very beneficial for wheat. Rain fell at some places in the State on practically every day of the month. It was the 4th consecutive month with temperatures averaging below normal. On the 29th freezing temperatures occurred as far south as northern Rice County, with some damage to the wheat crop. New low temperature records for so late in the season were established at a number of places on that date. Wheat continued in excellent condition and by the close was generally heading. Frequent rains hindered planting and cultivation of corn and grain sorghums and the curing of alfalfa.

June—Excessively wet weather prevailed, except in the southwestern and south-central counties, and temperatures generally averaged below normal, with excessive cloudiness. Farm work, including wheat harvest and corn planting, was delayed. Overflows occurred in practically all rivers of the State. Hail storms were numerous and damaging. The weather was generally favorable for wheat. Harvest with binders began in the south-central counties the latter part of the month and was in full swing with combines in the southern portion near the close. Corn planting and cultivation were hampered by the wet weather and the first cutting of alfalfa was extensively damaged in maturing.

July—Rainfall was deficient and generally of a local nature. The month averaged below normal in temperature but closed with a hot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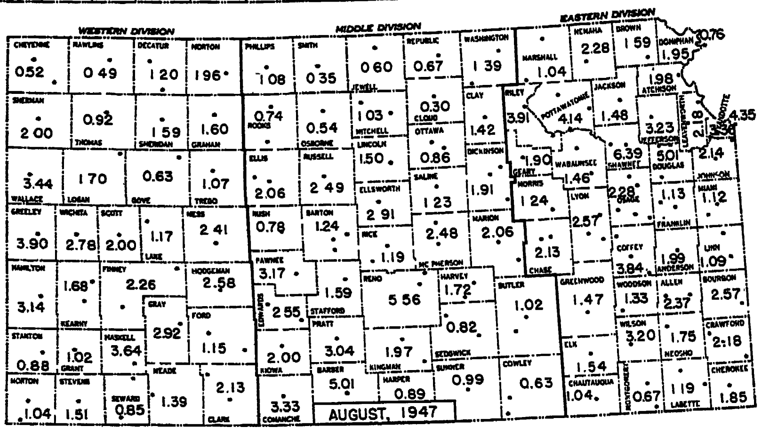
JULY, 1947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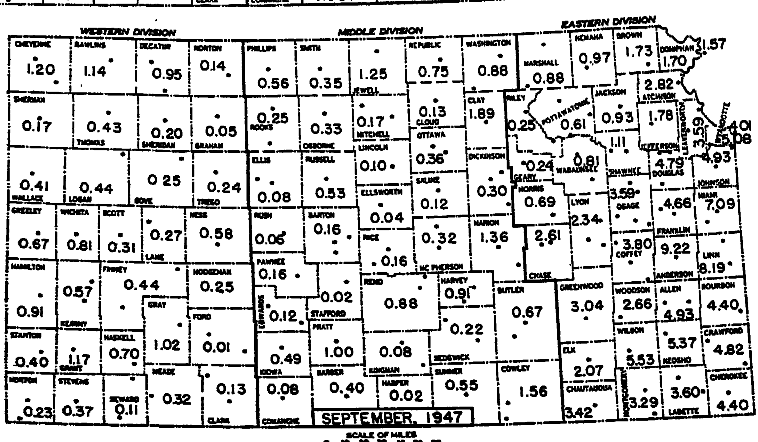
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SEPTEMBER, 1947
SCALE OF MILES

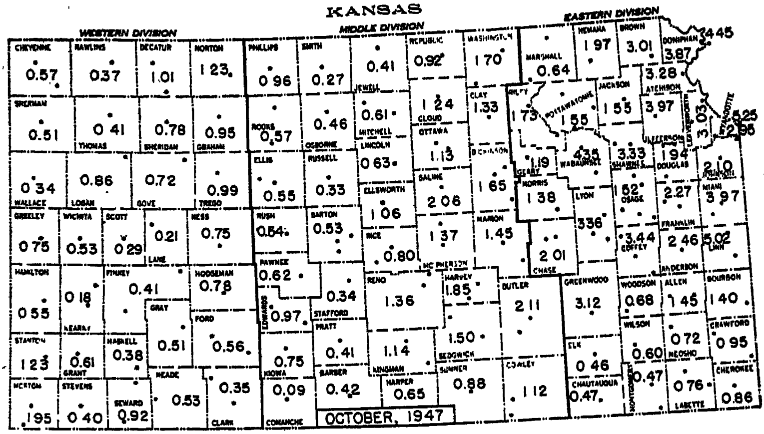
spell of almost record-breaking severity. It was a favorable month for the big wheat crop, which was practically completed by the close. Corn made excellent progress and generally reached the tasseling stage and withstood the hot dry weather with comparatively little damage.

August—Excessively hot dry weather prevailed. Rains were infrequent and were sufficient in only a few limited localities. Temperatures rose to or above 100° on from 10 to 15 days in nearly all parts of the State and nights were abnormally warm. Corn began to deteriorate early in the month and by the latter part much was damaged beyond recovery. Cutting the crop for silos was under way in a number of localities the last two weeks. Pastures deteriorated greatly.

September—Near record-breaking hot dry weather continued over most of the State this month. Only a few east-central and southeastern counties had sufficient rainfall and in most areas it consisted of one or two heavy downpours. In the middle and western thirds of the State this was one of the driest Septembers on record. A temperature of 117° at Lincoln on the 3rd was 4° higher than any other September reading on the state-wide record. Corn was further damaged by the hot weather. Development of grain sorghums was poor and pastures dried out to a great extent. Sowing wheat made little progress on account of lack of soil moisture.

October—This was the warmest October on record in the State and was deficient in rainfall, especially in the western counties, few of which had monthly totals exceeding three-fourths of an inch and a considerably number received less than half an inch. A high temperature of 104° on the 5th at St. Francis exceeded by 3° any reading previously reported in the State in October. No killing frosts occurred in the eastern two-thirds of the State except in some of the more northern counties. Sowing wheat made good progress over the eastern half but in the western half much wheat was not yet seeded on account of lack of sufficient soil moisture.

November—Exceptionally cool and cloudy weather with frequent though rather light rains characterized this month. In the north-central and western counties snowfall was frequent but melted fast. The first killing frost of the season occurred over most of the eastern two-thirds and southwestern counties from the 5th to the 12th, which are unusually late dates. Wheat over the eastern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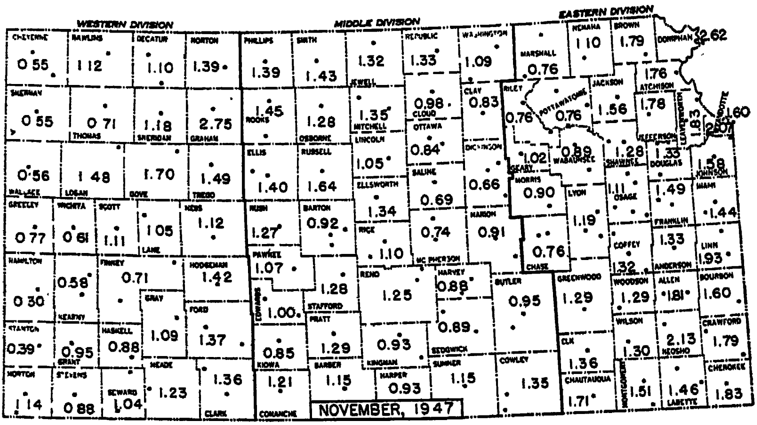
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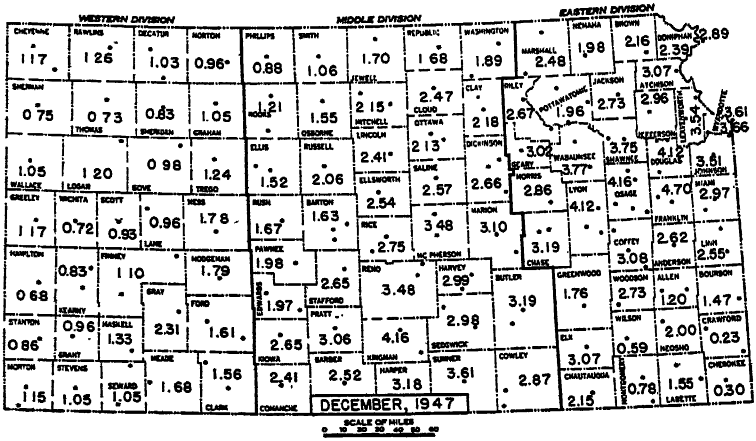
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DECEMBER, 1947
SCALE OF MILES

part of the State made good growth and generally covered the ground well, but in the western counties its growth was poor except on summer-fallowed fields.

December—Precipitation was generally heavier than in any other month since the previous June, averaging more than twice the normal amount. Temperatures were mild for the time of year, which made it a favorable month for the wheat crop.

The Climate of Kansas, 1871

Many flowing sentences and well rounded periods have been framed in the endeavor to describe the climate of Kansas. It has been called "Arcadia", but more frequently travelers who have been around the globe, and enraptured citizens who write to their friends in the East, call it an "Italian clime." In truth, it is neither Arcadia nor Italy—at least it is *not* one unbroken round of golden days and halcyon nights, but it is quite certain that there is no region in the United States, east of the Rocky Mountains, where there is more bright, sunshiny days than we have in Kansas. The winters are more mild than in the same latitude east of us, and the thermometer rarely sinks below zero. During midsummer the heat at noonday sometimes ranges for several days from 80 to 100 degrees, but the air is so dry and pure that one scarcely realizes the range of the mercury, while the nights are invariably cool and refreshing. Men work on buildings and in other exposed situations, with safety, at a temperature which would be fatal in the eastern States.

The soil is so fruitful that farmers never feel obliged to expose themselves to severe weather, summer or winter. Especially is our climate held in high esteem by those who escape to it from the extremes of northern frigidity, or from the torrid heats of southern latitudes.

It must not be forgotten that Kansas is a State of great extent and of various climate. Sometimes there are two or three inches of snow in the northeastern part of the State, which lays on the ground three or four days, and at the same time there will be no snow at all on the southern border of the State; at other times a light fall of snow may cover the State for a week, but there is no preparation made for sleighing, because there is rarely more than one such snow during a winter. Ice usually forms in December or January from four to eight inches in thickness, but rarely thicker than six inches, and two or three winters have occurred when no ice formed thick enough to store in ice houses. Farmers can plow during ten months of nearly every year in this State, and some years every month. I have seen masons laying stone and mortar during every month of the year, although not in every month in any one year, perhaps, because after building has generally ceased, and the hands are discharged and tools scattered, it is not customary to commence again until spring opens, which here occurs in February.

Still there are cold days here and people ought to come prepared for them; but there are also bitter cold days in Tennessee or Texas, and taking our average climate, it is mild and agreeable. Whenever, as during the past winter, it is very cold here, the telegraph always announces that it is colder in the same latitude east, and much colder north of us. During the past winter, 1870-71, we had three considerable snow storms; the first six inches deep. This was accompanied by almost continuous cold weather, sufficiently so to keep the ground covered with snow for four or five weeks. It has been, by far the severest winter I ever experienced in the State, and it is the universal testimony of the "reliable old settlers" that the snow never before laid on the ground so long.—From *Resources of Kansas,* C. C. Hutchinson, 1871.

The Stake of Business in American Education

FRANK W. ABRAMS

Frank W. Abrams is chairman of the board of directors of the Stand Oil Company of New Jersey. The paper below is based on an address m by Mr. Abrams last September and was published in The Lamp, *Standard Company (N. J.), through whose courtesy it is reproduced. It is not gen ally the policy of the* Transactions *to reprint material published elsewhere the editor feels that Mr. Abrams' remarks are an important contribution the serious problem of financing higher education now confronting us which we discussed editorially in our last issue. Irrespective of our individ attitudes toward "Big Business" we should be open-minded enough to consi any suggestion coming from this source. Mr. Abrams' views have been inforced in recent months by Mr. George A. Sloan, president of the Nutriti Foundation, an organization of large food industries. Mr. Sloan, speaking fore our sister academy of New York, urged industry to provide the ma support of scientific research and higher education.*

Whether "Big Business" is merely talking or whether they really me what they say—as based on the remarks of Messrs. Abrams and Sloan—u become apparent, we trust, by positive action.—The Editor.

Suppose you are a businessman and you have been called in direct the reorganization of an old, established enterprise—Amer can Education, Inc. You enter your office for the first time on Monday morning and proceed to take stock of the situation.

It is at once apparent that something is wrong. Production lagging and quality has fallen off. You have an enormous backlo of orders, but a great many of these orders are not being filled. Thos that are filled are not up to your traditional standards.

You investigate. The first thing you discover is that you hav a serious personnel problem. The enterprise is understaffed, and i many cases poorly staffed. On scanning your wage and salary list you find that your scale is far below the prevailing scale; you pa less than other enterprises, and as a result you are having difficult in getting enough of the right sort of people. Many of those now o the payroll were wartime additions who, responding to an emergenc need, have not had time to gain or maintain qualifications for the job

Because you are short-handed, everyone is overworked. Your employees are forced to sit up half the night trying to catch up with their work and preparing for tomorrow's problems. They get no extra pay for this.

As if this were not enough, you find that working conditions are bad. Your plant is frequently old-fashioned, and over-crowded. Some of your equipment is obsolete, and other tools are in such short supply that many of your employees are hampered in their work.

Largely because of factors beyond their control, your operating staff is at a very low level of efficiency.

But that is not all. The product of this enterprise is often out of date. Frequently it no longer meets the needs of the day.

Finally, you turn your attention to your stockholder relationships. You find that you have millions of stockholders, but that almost all of them are ignorant of the business and have little contact with it. They do not come to stockholder meetings. There seems to be an almost total lack of interest or understanding on the part of the people who own the business.

This last is a serious difficulty indeed—in the long run perhaps the most serious. For you can revamp your staff, rebuild your plants and introduce new production techniques, but you know, and every experienced businessman knows, the interest of the owners is a valuable incentive and support to a business.

A point which should be emphasized is this—*American business is one of the largest absentee stockholders in this enterprise.*

If we realize the extent of our "stockholdings"—our stake as businessmen in this business of American education, it will be not too difficult to establish that American business has every reason to help American education. We have something more than the normal interest of the good citizen who wants to see the world in which we live a better world for men of all faiths.

First, consider our direct selfish interest in people considered as markets. Markets are people. There is impressive evidence to show that the earning power, and therefore the purchasing power, of people tends to be geared to their level of education. Here are some high spots from a study of education and income made in 1927, but undoubtedly relevant today.

Take an untrained man with a grade school education. On the average, he goes to work at fourteen and reaches his top earning power at forty. Since his income is largely dependent on physical strength and manual dexterity, it begins to fall off at fifty or before. At age sixty the chances are better than even that he is dependent upon others for his support.

The average high school graduate goes to work at eighteen and within ten years is making more than the untrained man ever makes. He rises steadily to his own top earning power at age fifty, and falls off only slightly thereafter.

The average college or technical school graduate does not start steady work until he is twenty-two. By the time he is thirty he is

earning as much as the high school graduate does at forty, and his income continues to rise virtually without a break. Since it depends upon mental ability and training, both of which improve with practice, he continues to gain until he retires.

The study referred to is twenty years old, but undoubtedly the same approximate ratios apply today. At peak earnings, generally speaking, a high school graduate earns 65 per cent more than a grade school graduate, and the holder of an A.B. degree outstrips him by 250 per cent.

Today, 50 per cent of those in the highest income bracket are college trained, more than 40 per cent are high school trained, and less than 8 per cent are grade school trained. In the lowest income bracket these figures are almost exactly reversed.

Individual income or earning power is not the only factor that influences the expansion of markets. Education sharpens the desire of the individual for commodities such as books, newspapers, automobiles, better houses, and even the kind of food he eats. Statistical studies show a definite correlation between educational level, earning power, and the consumption of all commodities.

All of which means that the more high school and college graduates there are in this country, the higher standard of living all of us enjoy. That is simply another way of saying that the more graduates there are, the more prosperous customers American business and industry have.

Markets are one side of the coin. But obviously there is another. If education increases income, it also increases productivity. We may say, then, that business depends upon education not only to provide more profitable markets but to provide more productive manpower.

As every foreman knows, a worker who has had some practice in learning at school usually turns out to be better at learning in a factory. He catches on more quickly not only to the *how* of his job, but the *why* of it. His training takes less time. He has a quicker and better grasp of problems and ideas. He is more apt to think about what he is doing and to come up with useful suggestions concerning it. If he has gone through college, he has had an opportunity to acquire the broader perspective and the capacity to think in terms of ideas and trends, which are indispensable on the higher management levels.

If business and industry could not draw upon a large reservoir of educated manpower, they would be handicapped in every phase

of their operations. American education does a job for business and industry. If our hope of an advancing American economy involves reducing costs, increasing individual productivity, and devising better ways of doing things, we must consider that we have a major interest in helping American education and educators in their work.

Men without formal education have made spectacular records in America—in business and industry. That is always possible in a democracy. But the man who does that is a man who has succeeded in spite of handicaps. Certainly we cannot argue that business and industry generally can get along on the exceptional situation.

Most of you would probably agree that business and industry today have some of their principal problems and greatest opportunities in the field of human relations. We should not overlook the special value of education in this field. Analyses of public opinion surveys, for example, clearly show that the more education an individual has, the more likely he is to have an opinion. A recent study of the answers to more than 150 questions showed that only 7 per cent of those men and women who had demonstrated that they had information failed to express an opinion, whereas 28 per cent of people who had little or no information on a subject said they had no opinion.

The experts in this field are convinced that education produces not only a difference in the volume of opinion, but also a difference in the kind of opinion. People with information are inclined to more moderate opinions, whereas those without information are apt to be extremists.

Business and industry have an ever increasing interest in an educated population—an enlightened electorate. I cannot think of a healthier climate for any private enterprise.

The intelligence and initiative of people is a tremendous "natural resource" of any nation. All other natural resources are meaningless without it. Our position in the world today is not primarily a result of our other natural resources—although we have been fortunate in this respect—but to the ability which we as a people have developed. In this development our educational system has been a vital factor.

If we let our educational system decay, we will gravely injure the foundation of our greatness as a nation. By the same token, if we develop our educational system—expand it and make it stronger—we will be cultivating our greatest national resource, the people of America. And no one has a greater stake in the future of America than American businessmen.

Now, what can we do about it?

The most obvious answer is that business can give money to aid the cause of education. Of course, many corporations underwrite the expense of research projects in college and university laboratories which they feel will be valuable to their operations. Others grant scholarships.

These activities are excellent so far as they go, but they do not meet the basic situation which this meeting has been called to consider. We should recognize that endowed educational institutions are no longer able to find so many large private donors. There is a gap here which needs to be filled. Precisely how it is to be filled is hard to say at this time. But it is a problem which is clearly of concern to business and industry.

The matter goes deeper than grants and scholarships. A basic trouble with American education is public indifference. Something has got to be done to educate ourselves regarding the problem. All of us have got to understand it better, because the job which must be done will not be done by a few, but by the American people.

The situation which we as Americans should act upon has been ably stated in a variety of forms to reach the American people by the millions. The Advertising Council has done its job. It is ready for presentation either in magazine and newspaper space or on the radio. One service that business can perform for American education is to give this story the nationwide distribution which it deserves.

There is another thing that we as businessmen can do. We can give not only our money and our advertising facilities, but ourselves. If we hope to see this country grow and develop under the democratic system, let us devote ourselves personally to this task as one of our duties as citizens. Let us take part in educational affairs both in our home communities and at the national level. Let us urge our associates to do the same. This is a very important and very difficult problem. It deserves the best in all of us.

The Editor's Page

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ROBERT TAFT, *Editor*

Man's gravest problem at present is the prevention of war. We present "Atomic Energy For Peace—Not War" as our small share in emphasizing the need for action in the solution of this universal problem. The editorial was written by Dr. A. B. Cardwell, associate editor of these Transactions, *and head of the physics department at Kansas State College, Manhattan. During the war, Dr. Cardwell served as physicist at the Oak Ridge atomic energy plant and he therefore writes with understanding on the subject which should have our sober and continued consideration.*

Atomic Energy for Peace —Not War

In December, 1947, I again visited the spot under the West Stands of Stagg Field at the University of Chicago, where, on December 2, 1942, the first man-made, man-controlled nuclear fission chain reaction was realized. While there a question entered my mind: "Would the world be far better off if man were not cognizant of the methods we now have for releasing nuclear energy?"

That such a question should arise is an indication that we are far removed from the goal civilization should be seeking. All scientific knowledge should *aid* mankind in his efforts to master his material environment. In a truly civilized world it would be nonsense to think of using scientific knowledge to destroy. But today in the twentieth century the query does make sense.

The release of nuclear energy promises incredible advances and benefits in the years to come. No doubt successful and economic atomic power plants will be developed. But the greatest contribution from nuclear physics will come from the tools provided for research in all the physical and biological sciences. Already more than 600 radioactive isotopes have been produced, and many of these are now available for research. When these radioisotopes are introduced into a system, they behave as ordinary atoms of the particular element behave, but traces of these substances reveal their location by the radioactive rays they emit.

Tracer studies combined with other techniques will produce spectacular results. Many of man's most perplexing scientific problems will be solved, and unheard-of secrets of nature will be revealed. Cures for and methods of preventing many of man's

most dreaded diseases will result from these studies. Thus, man is in a potential position to make rapid progress toward mastering his physical environment.

But if these startling things to come are to produce a net constructive benefit in our changing world, the problem of maintaining peace must be solved. Atomic weapons must not be used to destroy civilization.

The cost of the second world war to the peoples of the world was one trillion two hundred sixty-five billions of dollars, but there are no units in which the cost of human suffering, agony, and lives can be measured. If we have another war, the cost in dollars and human suffering and lives will be increased at least one hundredfold. With newly developed nuclear weapons and the much more terrible biological weapons, combined with guided missiles, we know that in any future war we shall lose all our principal cities and millions of our citizens. Civilization, as you and I know it, will cease to exist and man's progress in mastering his physical environment will have been retarded untold centuries.

Are the peoples of the world so stupid that the newly discovered laws of nuclear physics shall be used to destroy man rather than to benefit him? The fact that such a question makes sense, indicates that it is time for men to think and act.

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

The 80th annual meeting of the Academy will be held at Pittsburg with Kansas State Teachers College as hosts on April 29 and 30 and May 1. One of the interesting aspects of the program is a symposium to be held Friday afternoon, April 30. The topic of the symposium "Recent Scientific Developments and Their Social Implications" will be discussed by Dr. L. D. Wooster of Fort Hays State College (biology), Dr. J. F. Hughes, Kansas State College, Manhattan (physical sciences), Dr. J. W. Nagge, Kansas State Teachers College, Emporia (psychology) and Dr. E. R. Walker, Oklahoma A & M College (social science).

As the meeting comes later in the school year than usual, mild weather should be an added incentive for attendance at the meeting. We trust that every member will make an effort to attend.

We publish in this issue the concluding number of Dr. H. H. Lane's extensive review "A Survey of the Fossil Vertebrates of Kansas." This important series began in our December, 1944, issue and succeeding parts appeared in the issues of December, 1945, of December, 1946, of

March, 1947, of September, 1947, of December, 1947, and of March, 1948 (the present issue). Collectively, the review runs to 278 pages. It is unfortunate that the funds of the Academy did not permit us to assemble the complete review as a monograph on the subject. However, the series has been exceedingly worthwhile and has done much to maintain and enhance the reputation of the *Transactions*. Not only are workers in the special field of paleontology indebted to Dr. Lane, but all members of the Academy are also in his debt for his time and talent in reviewing this field in a manner that makes readily available to the general scientific profession the widely scattered literature of Kansas animal paleontology. We again direct attention to the brief biographical sketch of Dr. Lane that appeared in our December, 1944, issue (p. 178).

Kansans have been greatly interested in the proposed chemical plant to be located in Garden City by the Stanolind Oil and Gas Company. An investment of some $80,000,000 will be made by Stanolind in converting gas from the Hugoton natural gas field into synthetic fuels and organic chemicals. The plant is expected to be complete by January, 1950, and will require a permanent force of some 600 persons to staff its operations. Through the courtesy of Mr. R. O. Karns, assistant to the president of Stanolind, the following data has been secured.

Mr. Karnes estimates that the production of water-soluble oxygenated chemicals from this unit will be as follows:

	Pounds/Year
Methyl alcohol	730,000
Ethyl alcohol	63,680,000
Propyl alcohol	14,400,000
n-Butyl alcohol	4,370,000
n-Amyl alcohol	1,060,000
Acetaldehye	9,100,000
Propionaldehyde	1,930,000
n-Butyraldehyde	2,750,000
Acetic acid	24,700,000
Propionic Acid	8,700,000
n-Butyric acid	4,200,000
Acetone	11,200,000
Methyl ethyl ketone	4,780,000
Methyl propyl ketone	600,000
Methyl n-butyl ketone	350,000

A control laboratory will be maintained at the plant. It is not yet known how large a laboratory staff will be required or how much research work will be done at the plant.

Through an unfortunate error we credited the illustration in our last issue (December, 1947) on page 277 to Bernard Frazer. The illustration, a panoramic painting showing an elephant caught in an asphalt pit and followed by a sabre-toothed cat, was the work of Walter Yost. Mr. Yost, who made over a dozen panoramic paintings for the exhibits in Dyche Museum, University of Kansas, between 1939 and 1941, is a graduate of the School of Fine Arts at the University, and now teaches art in the Atchison Public Schools. The background paintings for the large diorama on the main floor of Dyche Museum were done by Mr. S. T. Dickinson of Lawrence. The work of both Mr. Yost and Mr. Dickinson comes in for much favorable comment from the constant stream of visitors to Dyche Museum.

At Fort Hays State College.

Delta Epsilon, a science honor society, has resumed regular meetings following cessation of activities during the war years. The organization includes all the departments of science on the campus and meets twice each month. Discussions are led by faculty members and advanced students.

Dr. H. H. Nininger, president of the Academy in 1924-25, writes a word of greeting and asks to be remembered to all his friends in the Academy. Dr. Nininger is now director of the American Meteorite Museum, Winsolw, Arizona, which opened on October 18, 1946. The Museum is located on Highway 66 opposite the famous "meteor crater." During the first year of operation over 33,000 persons representing every state in the Union and 43 foreign countries visited the Museum. Exhibits, lectures and a planned program of meteorite research constitutes the work of the Museum.

Drs. D. J. Ameel, H. T. Gier, and Otto Tiemeier, members of the zoology department, Kansas State College, Manhattan, have undertaken an investigation of the dietary habits of an animal well known to the Plains, the coyote. Nearly 200 carcasses of these animals, resulting from extensive hunts at Fort Riley, Garden City, Scott City, Topeka and elsewhere in the state, have been shipped to the department at Manhattan for post-mortem examination. Results so far indicate that coyotes feed largely on rabbits and field mice. A more detailed report on these studies will be published subsequently.

Dr. C. S. Smith, assistant curator of anthropology, University of Kansas, will lead a party of eight students in a course of advanced field archeology this summer. The areas selected for study will include part of the territory to be inundated by the waters behind the new Kanopolis dam and a second area near Fall River. Indian burial grounds in these vicinities will be examined for pottery, knives and other implements used by Kansas residents from 500 to 1000 years ago. Discoveries will be cleaned, preserved, catalogued, and subsequently studied.

Death has taken an undue toll among the scientific profession and members of the Academy during the winter months just passed. We report with deep regret the passing of the individuals listed below.

Miss Grace R. Meeker, a life member of the Academy since 1899, died at Ottawa, Kansas, on Dec. 4, 1947. Miss Meeker was for many years librarian of the Ottawa Public Library and her interest in natural scienee was responsible for attracting many students into this field.

Dr. Frank B. Dains, life member of the Academy since 1902, and president of the Academy for two years in 1909 and 1910, the only member of the Academy to be so honored since the turn of the century, died at his home in Lawrence on Jan. 5, 1948. Dr. Dains, one of the most active members of the Academy in his day, had a long association with Kansas science. He was assistant professor of chemistry at the University of Kansas in 1893, but left to return to the Univer-

sity of Chicago. After teaching experience at Chicago and abroad, he returned to Kansas as professor of chemistry in Washburn College, Topeka, in 1902. He returned to the University of Kansas in 1911 and continued to serve the University until his retirement in 1942.

Dr. T. D. A. Cockerell, honorary member of the Academy since 1908, died in San Diego, California, on January 26, 1948. Dr. Cockerell, dean of American naturalists, was for many years before his retirement in 1935, professor of zoology at the University of Colorado, and was widely known for his scientific writing. His article "The Colorado Desert of California" in the June, 1945, issue of these *Transactions,* atttracted wide attention both at home and abroad. A biographical sketch of Dr. Cockerell will be found in the June, 1945, issue of these *Transactions.*

Dr. George E. Abernathy, an Academy member since 1945, died at Pittsburg, Kansas, on Feb. 6, 1948. From 1920 until 1937, Dr. Abernathy was a member of the staff of the Kansas State College, Pittsburg. Since 1937, Dr. Abernathy had been in charge of work for the State Geological Survey in southeastern Kansas, with offices in Pittsburg, a position which he held at the time of his death. We publish posthumously a paper by Dr. Abernathy in the present issue.

Dr. C. O. Swanson, former member of the Academy, died at his home in Manhattan, Kansas, on Jan. 5, 1948. Dr. Swanson joined the staff of Kansas State College in 1906 and became head of the milling department of the college in 1923, a position which he held until his retirement in 1944. A recognized authority on the milling of flour, Dr. Swanson was the author of some 100 scientific papers in this field.

Appointments recently announced by the director of the Kansas State Argicultural Experiment Station include

Dr. Clyde Mueller who will come from Cornell University May 1 to succeed Dr. D. C. Warren in the department of poultry husbandry.

Dr. Franklin E. Eldridge who comes on March 1 from Cornell University to the department of dairy husbandry. Dr. Eldridge will work in genetics and dairy cattle breeding.

Mr. Edgar F. Smith, who received his master's degree in animal husbandry at Kansas State College last summer, has been appointed assistant professor in that department.

Mr. William K. Wieland is the new associate agronomist at the Garden City Branch Experiment Station. He will be in charge of a new project in irrigation.

The Kansas Forestry, Fish and Game commission's comprehensive project to convert nearly 19,000 acres of land in Barton County into the Cheyenne Bottoms game reserve will be completed late in 1948 or early in 1949, Director Dave Leahy reports.

Two phases of work remain to be done to provide water for the large area. The first phase is the erection of a dam with flood gates below the present Missouri Pacific railroad dam on Walnut

creek to divert water from the Walnut into the game reserve area. The second phase, scheduled for completion after the initial phase, comprises work to divert water from the Arkansas river to the Walnut, thence to the Cheyenne Bottoms.

Leahy reports that approximately 1,800 acres of additional land now are undergoing condemnation proceedings or are in the process of negotiation for purchase. Because of the value of the bottoms as an attraction to migratory waterfowl, 75 per cent of the land cost is being borne by the Federal government.

Dr. Ivan Birrer, professor of psychology at Fort Hays Kansas State College since June, 1947, has resigned to accept a position as statistical consultant for the Command and General Staff College, U.S. Army, Fort Leavenworth.

Dr. F. C. Gates, associate editor of these *Transactions,* and professor of botany at Kansas State College, Manhattan, has been appointed chairman of a committee of the National Ecological Society to prepare a cumulative index for the published 28 volumes of *Ecology.* Other members of the committee include Dr. J. Aickman of Iowa State College and Dr. Alfred Emerson of the University of Chicago.

Dr. Frank Byrne, department of geology, Kansas State College, Manhattan, spent January 24-31 attending conferences at the U.S. Geological Survey in Washington relative to work being carried on by the department in mapping areas of engineering construction materials located in Kansas.

Dr. Robert Taft, editor of these *Transactions* and professor of chemistry at the University of Kansas, spent the week of Jan. 26th at the National Bureau of Standards in Washington studying methods and equipment used in making physical measurements employed in chemical research.

The 87th birthday of Professor W. C. Stevens of the department of botany, University of Kansas, was celebrated by a portrait unveiling and reception on Feb. 21, 1948. The portrait of Professor Stevens by Bernice Lopez was presented to the department of botany by the Linnean Club of the University and was accepted for the University by Professor A. J. Mix, chairman of the department. An address of tribute to Professor Stevens was given by one of his former students, Dr. N. P. Sherwood of the department of bacteriology.

New Flannagan-Hope research projects announced by the State Agricultural Experiment Station, Manhattan, include *The Resistance of Newcastle Disease Virus to Certain Physical and Chemical Agents* by the department of bacteriology under L. D. Bushnell and L. E. Erwin.

Fat Rancidity in Eviscerated Poultry by the departments of chemistry and poultry husbandry under F. A. Kummerow and T. B. Avery.

Control of Plant Bugs and

Other Insects Detrimental to Alfalfa Seed Production by the department of entomology under R. C. Smith and assistant.

The Influence of Electromagnetic Radiation on the Asorbic Acid Content of Plants by the department of physics under A. B. Cardwell.

Development of Viable Inbreds in White Plymouth Rocks by the department of poultry husbandry under Clyde Mueller in cooperation with the North Central Regional Laboratory.

The Introduction, Multiplication, Preservation, and Determination of Potential Value of New Plants for Industrial and Other Purposes, and for the Preservation of Valuable Germ Plasm of Economic Plants by the departments of agronomy and horticulture under H. H. Laude, J. W. Zahnley, K. L. Anderson, C. O. Grandfield, L. R. Quinlan and R. A. Keen.

Dr. R. L. Parker, professor of apiaculture and state apiarist, department of entomology, Kansas State College, attended the annual meeting of the Apiary Inspectors of America, held at Salt Lake City, Utah, on January 14, 1948. Doctor Parker presented a paper entitled "Does Protection of Beekeeping Require Trade Barriers." He also was elected to the executive committee of the National Federation of Beekeepers Associations.

Organic Chemistry, a text book by Dr. R. Q. Brewster, professor of chemistry at the University of Kansas, has just been published (March, 1948) by Prentice-Hall, Inc., New York. The text, 850 pages in length, is listed at $5.50 and represents an up-to-date approach to organic chemistry. Designed for use in undergraduate classes, application is made throughout of the electronic conception of valence as applied to the reactions and properties of carbon compounds. Such an approach unifies and coordinates the complex phenomena and reactions in this field. Questions, problems, charts, tables, graphic formulas and bibliographies are generously employed to facilitate instruction and study.

The first meeting of the pest control operators of Kansas was held at Kansas State College, Manhattan, Kansas, on January 31, 1948. The meeting was sponsored by the department of entomology. Plans were discussed for an organizational meeting, and papers were given on insect and rodent control. Over 60 representatives from Kansas, Missouri and Oklahoma attended the meeting.

Construction work on the 11-million-dollar Kanopolis dam, eight miles northwest of Marquette on the Smoky Hill river, is virtually finished with only the sodding of half the downstream slope of the dam with buffalo grass remaining to be completed. All the stone rip-rap on the upstream face of the dam has been placed and the 18-foot crushed rock road on top of the 3-mile structure has been completed. This road will be for maintenance of the dam only and not for public use.

The huge concrete spillway is ready for use. All equipment is being moved out of the reservoir area, bridges used in the con-

struction are being torn out and roads abandoned.

The contractor has finished clearing the huge reservoir of all debris, including buildings, fences and trees. The area is being kept free of water until all equipment has been removed.

"Review of Recent Oil and Gas Developments in Kansas", four pages, by Dr. J. M. Jewett, University of Kansas, appeared in *The Mines Magazine,* November, 1947. Copies of the review, which includes a map and a table of oil and gas pool discoveries in Kansas, are available for distribution. They may be secured by addressing the State Geological Survey, Lawrence, Kansas.

A three-page description of the work of the Kansas State Board of Health and a brief review of its history has been prepared by Mr. Tom Page and published by The Bureau of Government Research, University of Kansas, Lawrence. Copies of the review can be secured by addressing the Bureau at the address above.

The Foundation for Industrial Research, University of Wichita, announces the availability of four $1000 graduate fellowships at the University of Wichita for the academic year of 1948-49. Fellowship are available to graduates of accredited colleges and universities in the fields of aeronautical engineering, chemistry, petroleum geology and bacteriology. Further details may be secured from the Committee on Scholarships and Student Aids, University of Wichita, Wichita 6, Kansas.

A research project, sponsored by the Julius Hyman Company of Denver, Colorado, was initiated January 1, 1948, at the Kansas Agricultural Experiment Station, Manhattan. The purpose of this project, under the supervision of the department of entomology, is to investigate the insecticidal uses of chlordane and related substances. The work will be conducted under the immediate supervision of Dr. Paul A. Dahm.

Recent publications of the State Geological Survey, Lawrence, Kansas, include the topics listed below. Each publication may be secured from the Survey for the mailing charge indicated.

1. A cross section of oil and gas producing rocks under Trego, Gove, Logan, and Wallace Counties, Kansas, and Cheyenne County, Colorado. This item is the fifth in a series of six cross sections in western Kansas. It measures 38 by 40 inches and is accompanied by eight pages of text. Mailing charge, 25 cents.

"Cemented Sandstones of the Dakota and Kiowa Formations in Kansas" by Ada Swineford (Part 4 of Bulletin 70) reports studies of cemented sandstones in central Kansas, tests of these materials showing that they are of excellent quality for use as construction materials. Illustrated. Mailing charge, 10 cents.

"Magnetic Survey of Southeastern Crawford County" by Dr. R. M. Dreyer (Part 5 of Bulletin 70) describes the magnetic technique employed in

mapping the geological structure of the area above and the possibility of locating zones favorable for the occurrence of lead, zinc, coal and oil by this method. Mailing charge, 10 cents.

Dr. L. R. Laudon, professor of geology and head of the department of geology, University of Kansas, has resigned his position to accept a professorship at the University of Wisconsin, Madison. Dr. Laudon will be succeeded by Dr. Robert A. Dreyer, since 1939 a member of the University staff, as head of the geology department.

Dr. Noble P. Sherwood for the past 30 years head of the department of bacteriology at the University of Kansas will retire July 1 as department head but will continue his teaching duties. Dr. Sherwood will be succeeded by Dr. Lawrence W. Slanetz now head of the department of bacteriology at the University of New Hampshire, Durham. Dr. Slanetz received his undergraduate degree at Connecticut Agricultural College in 1929 and his doctorate from Yale University in 1932.

Reports of the Presidents Commission on Higher Education of which President M. S. Eisenhower of Kansas State College, Manhattan, was a member, are now available in five volumes. As these reports represent nation-wide planning for the future of college and university training in this country, their study and consideration are of utmost importance to all forward looking teachers and administrators. For teachers, volumes I and IV of the reports *Establishing the Goals* and *Staffing Higher Education* should be of special interest.

The titles of the individual reports and the price for which each can be secured from the Supt. of Documents, Government Printing Office, Washington, D. C., is given below.

Volume I, *Establishing the Goals,* 103 pages, 40 cents.

Volume II, *Equalizing and Expanding Individual Opportunity,* 69 pages, 35 cents.

Volume III, *Organizing Higher Education,* 74 pages, 30 cents.

Volume IV, *Staffing Higher Education,* 63 pages, 25 cents.

Volume V, *Financing Higher Education,* 68 pages, 25 cents.

Dr. Robert E. Stowell, formerly assistant professor of pathology, Washington University, St. Louis, has been appointed professor of pathology, in the University of Kansas school of medicine, Kansas City. Dr. Stowell, whose appointment became effective March 1, will head an extended program of study, teaching and research in the field of cancer and cancer prevention. The cancer research program will occupy the entire second floor of the Hixon Laboratory in the medical school and a staff of ten members, it is hoped, will be at work by mid-summer. Included in the staff will be physicists, biologists and biochemists. Dr. Stowell received his undergraduate and medical training at Leland Stanford University and received his doctorate in pathology at Washington University in 1944.

Survey of the Fossil Vertebrates of Kansas: Part V: Mammalia

(Concluded from the December, 1947, Issue)

H. H. LANE
University of Kansas, Lawrence.

Order Artiodactyla:

The even-toed mammals with hoofs are those which anciently were termed "cloven-hoofed", though this is a matter of external appearance only, and not of actual fact. They constitute what is today a well-defined group, known technically as the *Order Artiodactyla*—a name derived from the Greek *artios,* even, and *dactylos,* finger. The living artiodactyls fall very naturally into two suborders, but it is very difficult, in fact impossible, to place all the extinct forms in these two subdivisions. Fortunately for us, the fossil families of this order in Kansas, with only one exception, belong clearly to the two suborders referred to, namely, the *Bunodonta,* or hogs and their kin, and the *Selenodonta,* including all the rest. The distinction between these two groups is sharp in respect to teeth and feet, as well as in various parts of the soft anatomy. Thus all the bunodonts (from the Greek, *bounos,* a hill, *i.e.,* rounded, and *odous, odonti-,* tooth) have round-cusped crushing cheek-teeth, powerful canines in the form of long, often curved tusks that are triangular in cross-section; four-toed feet (reduced to three on the hind feet of modern peccaries) with the metapodials (*i.e.,* the metacarpals and metatarsals) more or less completely separate, that is, not fused into one so-called "cannon bone". The selenodonts (from the Greek, *selene,* moon, and *odous,* tooth) all have crescentic cusps on the cheek-teeth, of which the premolars have two, the molars four cusps. Their upper incisors are reduced or absent, while their lower incisors, and usually the canine also, are small, spatulate, and forwardly directed; the feet are two- or four-toed, with the middle pair of metapodials fused into a "cannon bone".

The one exceptional family among the artiodactyls of Kansas is that usually called the *Oreodontidae,* or, more lately, the *Merycoidodontidae,* in which the cheek teeth are selenodont like those of the ruminants, or cud-chewing ungulates, such as the cow or sheep, but with tusks resembling those of the peccaries, except that the lower tusk is the *first premolar* instead of the canine, which re-

sembles an incisor. The incisors form a full set, *i.e.,* are present above as well as below, and are of the cutting or cropping type, more like the condition in the horse, and unlike those either of the hogs or ruminants. The feet of the oreodonts are short, four-toed, somewhat resembling those of the hogs, but still more like some of the even more problematical extinct families of the artiodactyls. While the oreodonts are sometimes nicknamed "cud-chewing pigs", they are only very distantly related either to the hogs or to the ruminants.

Until a few years ago no oreodonts had been found in Kansas. In 1941, Schultz and Falkenbach published a paper in which they set up a new subfamily of these artiodactyls under the name *Ticholeptinae,* comprising three genera, one of which, *Ustatochoerus,* was new and includes three species from Norton County, Kansas. The specimens from this state are recognized by these authors as "geographic varieties", distinguished by size and proportions, as well as by other more technical characters, from the more typical forms from Nebraska and South Dakota. The genus *Ustatochoerus* seems to have had a wide range of distribution in the Great Plains area from Montana and South Dakota through Nebraska, Kansas and Colorado to Texas, New Mexico and California. The type of *Ustatochoerus medius* was collected by F. V. Hayden in 1857 "in the sands of the Niobrara River", probably in what is now Cherry County, northern Nebraska, and was described in 1858 by Joseph Leidy under the generic name of *Merychyus;* it is recorded from Norton County, Kansas, by Schultz and Falkenbach. The second species, *Ustatochoerus profectus,* was described in 1909 by Matthew and Cook as *Merychyus* (*Metoreodon*) *profectus,* from Sioux County, Nebraska; it is recorded by Schultz and Falkenbach from Norton County, Kansas. The third is a new species, *Ustatochoerus skinneri,* described by the latter authors in 1941 from Turtle Buttes, Tripp County, South Dakota and is likewise recorded by them from Norton County, Kansas. All these specimens from this state are too fragmentary for other than a technical description, which it is not necessary to give here.

Among the bunodonts, only the family *Tayassuidae,* or peccaries, is represented by fossil species in Kansas. According to the recent studies of Pearson in Europe and Colbert in this country, it has been shown that the true hogs and peccaries had a common Eurasiatic origin at least as far back as the Lower Eocene—possibly even in the Paleocene. This stem divided before the close of the

Eocene, giving rise to divergent yet still very similar forms in Oligocene time represented by the genera *Palaeochoerus* and *Perchocrus*. The former, confined to Europe, was the progenitor of the true hogs, while the latter was in the line of the peccaries. The latter line forked again in the Upper Eocene or Lower Oligocene into an Old World branch to which belong the genera *Dolichochoerus* of the Oligocene and *Pecarichoerus* of the Lower Pliocene, in Europe and Asia respectively, while the second branch migrated to America, where *Perchocrus* was the Oligocene representative of the peccaries on this continent. *Perchoerus* was succeeded by *Prosthennops* of the Miocene and Pliocene, and *Platygonus* of the Pliocene and Pleistocene. The Old World line of peccaries died out in the Lower Pliocene, while in America descendants of *Prosthennops* and *Platygonus* are the living peccaries (*Tagassu*) of South and Central America, Mexico and the southwestern states of Texas, New Mexico and Arizona.

Figure 1. Collared Peccary: photograph from life and used by permission of the Smithsonian Institution, U. S. National Zoological Park, Washington, D. C.

The living peccaries (Fig. 1) are pig-like in form, about three feet long and two feet high at the shoulders, externally without a tail, and weigh 45 to 50 pounds. They are gregarious, omnivorous, and root like a hog with a pig-like snout. They have a strong and characteristic odor produced by the secretion of a gland located on the doral surface of the body.

The first of the two fossil genera from Kansas is *Prosthennops,* which has been recorded from the Middle Pliocene, Edson beds, of Sherman County (KUMVP, No. 3609). This is the species *Prosthennops serus* Cope, which has also been listed from the Republican and Smoky Hill River deposits of northwestern Kansas, while *P.* cf. *crassisignis* Gidley is known from the Smoky Hill River. In *Prosthennops* the upper incisors are small and the outer one above (the third) has been lost, as has also the first premolar in each jaw. Hence its dental formula is: I-2/3 C-1/1 P-3/3 M-3/3=36. There is a short diastema, or toothless space, between the canine and the second premolar. The third and fourth premolars resemble the molars in form.

Figure 2. Platygonus, a Fossil Peccary. Photograph by Photographic Bureau, University of Kansas, of specimen in the KUMVP.

The second of the two fossil genera from Kansas is *Platygonus* (Fig. 2), in which the diastema is long and the second premolar is simple in form. The cusps of the molars are united to form ridges (*lophs*). The lateral toes are lacking. In 1894 Williston described a very interesting find of *Platygonus,* which he identified as *P. leptorhinus,* but which should probably be known as *P. compressus,* from Goodland, Sherman County, Kansas. In excavating for clay in a brickyard, nine skeletons were found which belonged to individuals of both sexes and of different ages, indicating that this species was gregarious in habit like the living peccaries. The bones

were found, as reported by Williston, in a loose sandy marl at a depth of nine feet. The different individuals were lying with their snouts all pointing in the same direction and those behind were resting partly on those in front; probably a small herd had perished in a storm, perhaps a sudden blizzard such as is common today on the plains. While Williston regarded the deposit as Pliocene in age, it is more likely to be regarded as Pleistocene. It is evident that the bones were buried in loëss, which is so common in that region.

Hibbard has recorded a *Platygonus*, species undetermined, from the Blancan formation, Rexroad fauna, of Meade County, which is either late Pliocene or early Pleistocene, probably the latter. This genus is also known from the Lower Kingsdown, Upper Pleistocene, of Clark County. This is evidence that supports the conclusion, previously based on finds in Nebraska, that *Platygonus* persisted throughout most or all of the Pleistocene.

Dr. A. Smith-Woodward, in his lifetime a noted vertebrate paleontologist of England, once pointed out the very interesting fact that "as the series of Suidae [hogs] and their allies are traced upwards, the molars sometimes exhibit phases of development curiously like those to be noticed among the Proboscidea [elephants]. *Listriodon* [a hog], from the Middle Miocene of Europe, exhibits lophodont teeth remarkably similar to those of Dinotherium [an elephant]; the molars of many pigs are miniatures of the corresponding teeth of *Mastodon;* while the hindermost true molar of the existing Wart-hog (*Phacochoerus*) of Africa is in structure not unlike the molar of *Elephas*. It is also to be observed that, in such persistent old types as the peccaries, the canines become transformed into tusks of persistent growth."

The third family of artiodactyls with fossil representatives in Kansas is that of the camels (*Camelidae*), a family which constitutes a suborder that occupies at one and the same time a *central* and an *isolated* position in the Order Artiodactyla. This suborder is termed the *Tylopoda,* a name indicating one of the chief camelid peculiarities, namely, their "padded" feet (from the Greek, *tyle,* pad, and *pous, podis,* foot). The genealogical history of the camels is very well-known from the fossil record and is second only to that of the horses in its completeness. Surprisingly enough, almost their entire evolutionary development took place in North America, where they are now extinct, the only living representatives of the family (*Camelidae*) being comparatively late emigrants, on the one hand

into South America, and on the other into Asia and Africa. For these reasons, and the additional one that no less than six genera of these mammals are known as fossils from Kansas, they are of especial interest to us here.

The camels began in the Eocene in forms very closely related to the ancestors of the other cud-chewing artiodactyls. While retaining many primitive characters, they, nevertheless, early became specialized along their own lines. Among the primitive features still retained is the separateness of the bones making up the ankle (*tarsus*) and the wrist (*carpus*), which in other artiodactyls have fused together to a greater or less extent. The dentition in the camels has been modified less than in the other ruminants, though there have been some special changes in the form and reduction of certain teeth. Their limbs are long and there are but two toes on each of the feet; the metacarpals and metatarsals are fused to form long "cannon bones", *the lower ends of which are forked.* The stomach in the living camelids is only *three-chambered,* whereas in the other ruminants it has *four* chambers, or subdivisions. The red blood-corpuscles in living camels are elliptical, instead of circular in outline, a feature in which they differ from all other mammals. While the Old World camels of today have one or two humps on the back, the South American representatives of the family lack this feature. Whether any of the extinct species had a hump cannot be determined since this structure entails no modification whatsoever in the skeleton. In a well-conditioned animal it is merely a conical sack of skin filled with a mass of gelatinous fat, and is clearly an adaptation to desert life. In the stomach both the first and second chambers are unique in the presence of a number of flask-like pouches, or "canteens", for the storage of a reserve supply of water, obviously another adaptation to life in the desert, where oases, with water, are few and far apart. This peculiar structure of the stomach was evidently developed before the camels left America, for the South American forms also have it, though they live in mountains as well as on the pampas and have not been subject to desert conditions.

The earliest known camels were no larger than a jack-rabbit, so that one of their evolutionary changes has been increase in size, some of them finally becoming gigantic before extinction in the Pleistocene. The loss of the lateral toes is another such feature. While the earliest camelids were unguligrade, with feet and hoofs very much like those of a deer, in the Pliocene and later forms the

feet are digitigrade, with broad phalanges underlain with pads, and the hoofs are reduced to little more than flat nails. In the grazing forms, the teeth are somewhat reduced in number, but the remaining ones are usually elongated. The first and second upper incisors have been lost, the third or outer one remaining but modified in shape to resemble a canine. The first upper premolar is absent, while the second is also caniniform. In the lower jaw, the incisors are large and shovel-like in form, while the first and second premolars are both lacking. The molars have four crescentic cusps and are high-crowned in both jaws. The head and neck are elongated, the latter being very long. In the skeleton, the most noticeable feature is the very long femur (thigh bone), which carries the knee-joint well down below the body. The ulna and the fibula are reduced to mere vestiges, coössified in the case of the ulna with the radius.

While externally, owing to the absence of a hump, the South American llama and its kin look quite unlike the Old World camels, internally their resemblances are numerous and striking, and both groups connect anatomically without a break with known extinct forms.

The oldest known fossil camels in Kansas have been reported from the Middle Pliocene, Edson beds, of Sherman County. These belong to two genera, *Megatylopus gigas* and an undetermined species of *Pliauchenia.* The former species was first described from the Lower Pliocene of Arizona, and, as the name suggests, is truly a gigantic camel with a height of fifteen feet. It apparently was not a long-lived species, and here again we find gigantism leading soon to extinction. *Pliauchenia* was a large llama-like form, which however was not directly ancestral to the living llamas, for it had lost three of its premolars in each jaw, above and below. Its generic distinction is based upon the absence of the second lower premolar, in which respect it differs from all other camelids. This was an important step in the dental evolution of the camels and justifies the generic assignment of the species displaying it. Cope, many years ago, described a specimen "from the Loup Fork Beds of Long Island, Phillips County, Kansas", which is now known as *Pliauchenia humphresiana.* In size this species about equals the smaller individuals of *Procamelus occidentalis,* but has long narrow molar teeth. Another species, known as *Pliauchenia minima,* is the smallest camelid yet known from "the Loup Fork deposits", according to Wortman. The type specimen came from Decatur County, Kansas. It was about the size of the little *Poëbrotherium labiatum* of the

White River Oligocene (Fig. 3), that is, about the size of a sheep, but with relatively longer legs.

Figure 3. Poebrotherium, an Oligocene Camel. Photograph of a diorama by Bernard Frazer in the KUMVP.

Another gigantic camel may be listed as *Megacamelus* sp. (*?Colossocamelus* sp.) with a head about thirty inches long, from the Blancan formation, Rexroad fauna, of Meade County, Kansas, where, associated with it is a large llama-like genus known as *Tanupolama*. This material is in the University of Kansas Museum of Vertebrate Paleontology and was discovered and collected by Mr. E. S. Riggs; to date it has not been completely studied.

Perhaps the most common extinct camel in Kansas is *Camelops*, of which two species have been recorded from this state, besides a number of other specimens the specific identification of which is undetermined. This genus, apparently originating in the early Pleistocene, persisted not only to the end of that epoch, but lived even into the Recent time in our western states. A specimen of *Camelops* was found a few years ago in a cave near Fillmore, Utah, that was in a remarkedly fresh condition, as reported by Romer. No mineralization of the bones had occurred, and fragments of dried muscle tissue still adhered to the skull. The animal was young, and the conclusion of Romer is obvious, namely, "that a native camel, supposedly extinct since the early Pleistocene, has existed recently in the Great Basin region."

The genus *Camelops* thus takes on added interest, since it was without question contemporaneous with man in North America, and not unlikely lived here within the Christian era. It is well known

from complete skeletons recovered from the Rancho La Brea asphalt pits near Los Angeles, California. It was a very large camel, reaching a height of seven feet at the shoulders, or at least eight feet to the top of the head when in the usual standing position. While *Camelops* has structural resemblances both to *Llama* (Fig. 4) and *Camelus*, the two living genera, it was in other respects different from both and has left no descendants.

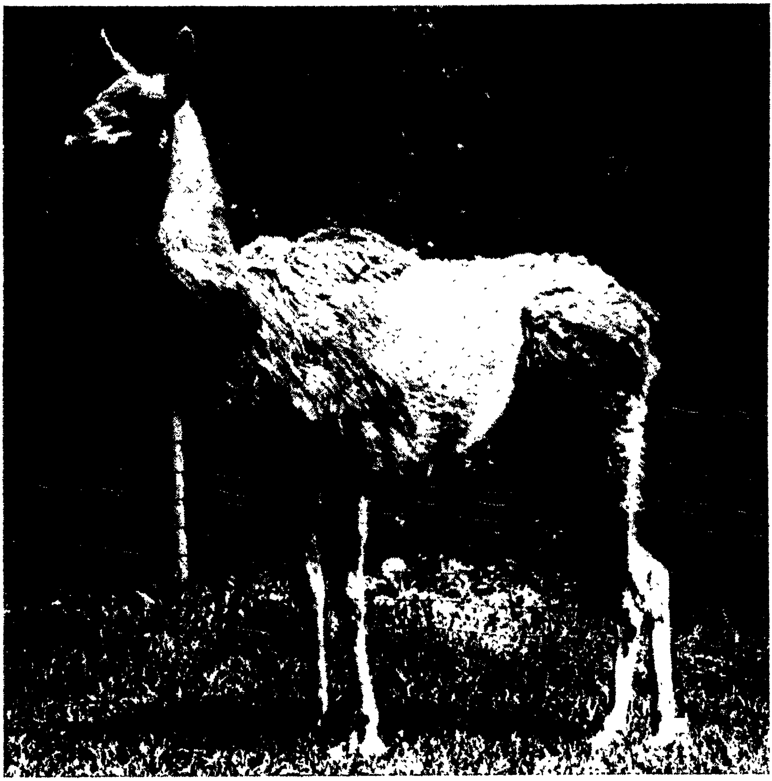

Figure 4. Guanaco, a living South American Camel. Photograph used by permission of the Smithsonian Institution, U. S. National Zoological Park.

Many years ago (1854) Joseph Leidy proposed the name *Camelops* for a specimen from the Pleistocene gravel drifts of Kansas. Specifically he designated it as *Camelops kansanus*. The dental formula in this species is: I-1/3 C-1/1 P-2/1 M-3/3=30. In size it about equals the modern one-humped Dromedary, although some specimens are decidedly more robust, while others are more slender than the living form. Leidy's type specimen is presumably

in the museum of the Philadelphia Academy of Sciences. O. P. Hay records this species from Leroy, Coffey County; from Pendennis, Lane County; from Russell Springs, Logan County; and from McPherson County. More recently it has been recorded from the Pleistocene of the Pyle Ranch in Clark County; from the Big Springs Ranch in Meade County; while there is an additional record from McPherson County. Specifically undetermined specimens are known from the Borchers fauna, Pleistocene Interglacial, of Meade County. Cragin, in 1890, described a species of camel, now known as *Camelops huerfanensis* from Spring Creek, Meade County, in the "Meade Gravels". However, Wortman and Hibbard think that *C. huerfanensis* cannot be distinguished from *C. kansanus*. Hibbard also refers to *Camelops* sp. some camel remains from the Blancan formation, Rexroad fauna, of Meade County. Associated with these remains were those of another smaller intermediate camelid species.

The last species of fossil camel to be recorded here from Kansas is one known as *Eschatius conidens* Cope, reported by Riggs from the late Pleistocene exposure along Shorts Creek, Meade County (KUMVP, No. 4799). This genus was the most specialized of all known camels, living or extinct. One striking modification in *Eschatius* is the extreme transformation of the fourth upper premolar into a simple cone, correlated with which is the greatly reduced lower canine—two features found in no other camelid.

In the Kansas specimen the much reduced fourth upper premolar is a conspicuous feature. However, this individual was evidently a young animal as is shown by the posteriorly open cleft in the anterior lobe of the first molar into which the convex margin of the second lobe extends. Moreover, the Kansas specimen is somewhat smaller than Cope's type of *Eschatius conidens* from the "Valley of Mexico". There is therefore to be kept in mind the possibility that the Meade County individual is an immature *Camelops* or some other camelid genus.

As the genus *Eschatius* is known from Oregon as well as from Mexico, its occurrence in Kansas would indicate a very wide geographical distribution. In size Cope's type about equals that of the living Dromedary.

Family Cervidae:

The family of the deer (*Cervidae*) was a comparatively late arrival in North America from Asia, at least in so far as the larger types are concerned. The smaller Virginia Deer (*Odocoileus virginianus*) and its relatives, however, are exclusively American and

therefore undoubtedly must have had a much longer existence on this continent than the others, which arrived in the Pleistocene, but the paleontological record is lacking in any direct support for this hypothesis. All the American deer, at least in the males, have deciduous antlers that are shed annually (in the Caribou, the female also has antlers). These are solid bony structures without a sheath of horn such as is present in cattle, sheep and goats. These antlers grow from permanent bases on the frontal bones of the skull posterior to the orbits. During growth, the antlers are covered with vascularized tissues and skin with downy hair, constituting the so-called "velvet", which dries up and is rubbed off when the antler is fully developed. In general, the antlers grow larger and have more "tines" or branches each year until the maximum is reached usually about the sixth or seventh year, the larger species having, of course, the larger antlers, which in a few cases are of gigantic size. In most forms, the beam and tines of the antlers are nearly cylindrical and taper to a point, but in some, such as the Moose and the extinct *Cervalces,* they are broad and flat, somewhat in the form of a gigantic hand with outstretched fingers, hence termed "palmate".

Figure 5. Virginia Deer. Photograph by the K. U. Photographic Bureau of a group in Dyche Museum of Natural History, University of Kansas.

Three genera of fossil deer have been recorded from Kansas, two of which have living representatives. One of these is the Virginia Deer (*Odocoileus virginianus*) (Fig. 5) from the late Pleis-

tocene, Rezabek fauna, of Lincoln County, and also from Douglas and Harvey Counties. This may even represent the subspecies, *O. v. macrourus,* formerly a common inhabitant of the Great Plains from Alberta on the north to New Mexico on the south and westward to the Rocky Mountains. This form is too well known to warrant further account here.

The second genus with fossil remains recorded from Kansas is the Wapiti or the mis-called "American Elk", which is really a stag

Figure 6. Wapiti. Photograph by the K. U. Photographic Bureau of a group in Dyche Museum of Natural History, University of Kansas.

and not an elk. The latter name should have been applied to the Moose, which is a very near relative of the Old World Elk. The Wapiti (*Cervus canadensis*) has been recorded from the Pleistocene of North Lawrence, and from Wakarusa Creek, both in Douglas County. An undetermined cervid has also been recovered from the Rexroad fauna, Blancan formation, of Meade County. The Wapiti (Fig. 6) is a magnificent species which reaches an extreme length of more than 9½ feet in the male, which is much larger than the female. The height at the shoulder may be as much as five feet and the weight up to 1000 pounds. The female may reach a maximum length of 7⅓ feet; height at the shoulder of 4 2/3 feet, and a weight of 600 pounds. Record antlers with 7 or more tines have a spread of 5 feet or more.

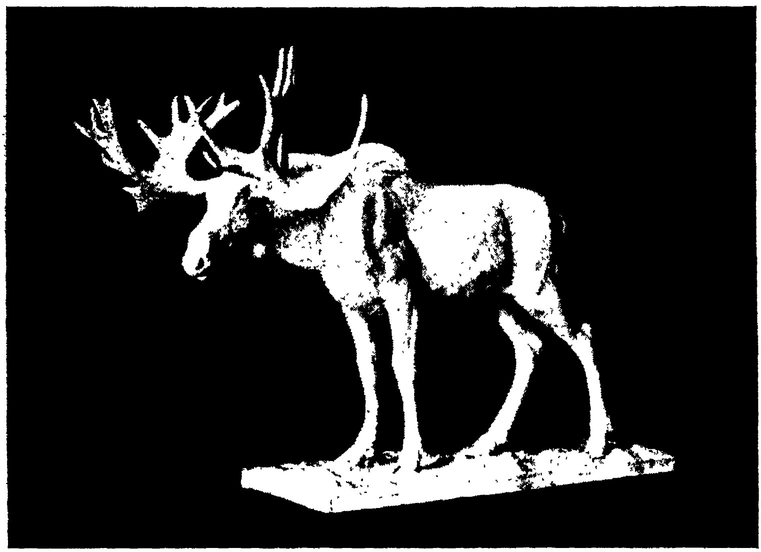

Figure 7. Cervalces, fossil Moose-like Deer. Photograph of restoration of the type specimen in the Princeton University Museum by the late Dr. Charles Berryman Scott.

The third genus of fossil deer from Kansas is known as *Cervalces scotti* (Fig. 7) and was in life about the size of the Moose. It has been recovered from the late Pleistocene sand in the Kaw (Kansas) River at North Topeka, Shawnee County (KUMVP, No. 5069). It is sometimes called the "Stag-Moose" and differs in several respects from any Pleistocene or later species in this country. Most of the specimens so far recovered have been fragmentary, but one complete skeleton of post-glacial age is in the Museum of Prince-

ton University, and is very similar to that of a moose. The chief differences are found in the longer nasal bones, indicating that *Cervalces* did not have the inflated snout of the moose, and in the antlers which are less palmated and carry a very large curved plate arising from the under side of the beam—a feature not found in any other deer. Though known as yet only from North America, its evident relationship to the Moose indicates that it too must have been an Asiatic derivative. *Cervalces,* while a very large deer, yet was surpassed in size by the so-called "Irish Elk" of Europe, whose enormously palmated antlers sometimes had an expanse of over eleven feet.

The family *Antilocapridae* is an isolated branch of the Artiodactyla known only from North America where its first representative, *Merycodus,* occurs in the Upper Miocene and Pliocene. Since there are no known ancestral antilocaprids in the Oligocene and Lower Miocene of this continent it seems very likely that *Merycodus* represents an immigrant group from Asia in the Lower Miocene that had its origin in common with the antelopes, sheep, goats, and their kin. The members of the *Antilocapridae* are small to medium-

Figure 8. Pronghorn. Photograph by the K. U. Photographic Bureau of a group in Dyche Museum of Natural History, University of Kansas.

sized ungulates, both sexes of which have branching ***deciduate horns*** borne on ***permanent bony cores.*** In the single living species, the Pronghorn (*Antilocapra americana*) (Fig. 8), the slightly curved horn-cores are simple, but the sheaths each have one fork and are shed and renewed annually. In some extinct antilocaprid species the horns were twisted spirally like those of certain African antelopes today; several others had *four* horns instead of *two,* as, for example, *Capromeryx,* known from the Pliocene and Pleistocent, from Nebraska and Kansas westward to California and southward into Mexico. Complete skeletons of *Capromeryx* have been recovered from the Rancho La Brea asphalt pits near Los Angeles. This form was less than two feet high at the shoulders. Its molar teeth were high crowned and adapted to grazing. Its premólars were reduced to three above and two below. Its horn-cores, each with a rudimentary anterior prong, were less than half as large as those of the living *Antilocapra,* and were situated somewhat farther back than in the latter genus in which the horns arise just above the orbits of the eyes.

Capromeryx sp. (KUMVP, No. 3944) is doubtfully identified by Hibbard from the Rexroad fauna, Blancan formation, Upper Pliocene, of Meade County. Fragments of nine specimens from the Rhino Hill fauna, Middle Pliocene, Ogallala formation, Wallace County, and one from the Tertiary beds of Clark County were recognized as *Capromeryx altidens* by Hesse. However, Frick tentatively refers *C. altidens* to his new genus *Texoceros.* To another new genus, *Plioceros,* the latter author refers a species, apparently related to *C. altidens,* from "Beaver Creek, Kansas", probably in Rawlins County. This specimen, which Frick calls *Plioceros dehlini* var. (F:A.M No. 31513), consists of only a few foot bones and this assignment is marked as questionable by Frick himself.

To his genus *Ramoceros,* Frick refers a new species, which he calls *Ramoceros* (*Paramoceros*) *kansanus* (F:A.M. No. 31510), "from M. F. Frake's ranch, 16 miles S-E of Trenton, Nebraska", which puts it just south of the Kansas-Nebraska line in Rawlins County, Kansas. The type consists of a fragmentary horn-core, a mandible, leg and foot bones. To the same species Frick also assigns the fragmentary remains (F:A.M. No. 31512) of another specimen "from north fork of Sappa Creek, northwest of Achilles", again in Rawlins County.

To the genus *Cosoryx,* Frick refers two additional specimens—one (F:A.M. No. 31515) "from Republican River Beds, Phillips

County", which he considers to be a "variety" of *Cosoryx furcatus* Leidy, described in 1869 from Nebraska. As a new subspecies of *Cosoryx furcatus,* Frick cites a partial skull, horns, and mandible "from Section 1, 2 miles south and ¾ mile east of Dinsmore", evidently a *lapsus plumae* for Densmore, Norton County; this he calls *C. furcatus sternbergi* (F:A.M. No. 31511), in honor of George F. Sternberg, of Hays, Kansas, who collected it.

Fossil remains of the Pleistocene and Recent Pronghorn, *Antilocapra americana,* have been obtained from the bank of Wakarusa Creek, Douglas County, a few miles southwest of Lawrence, and from the Borchers fauna, lower Upper Pleistocene, of Meade County. Probably as numerous as the bison in Kansas when the state was first settled, the Pronghorn melted away before the plow and gun until a few years ago the last remnant vanished in Morton County, probably never to return, at least in any considerable numbers.

Family Bovidae:

The family of artiodactyls which includes the cattle, bison, buffaloes, muskoxen, sheep, goats and antelopes, is called the *Bovidae.* In all these forms the males of every species as well as the females in most instances possess true horns located on the frontal bones of the skull. These horns consist of two parts: (1) an internal "core" of bone into which air cells often extend from the frontal sinuses, and (2) a "sheath" of horn covering the core externally and extending far beyond it at the extremity. Essentially the horny sheath is an epidermal structure, like a solid mass of thick hair cemented together, which grows continuously from the base as it wears away at the tip. Unlike the antler of the deer, or the forked horn of the Pronghorn, no part of the bovid horn is ever shed. For obvious reasons horns are not present at birth but begin to develop immediately afterwards.

The form, size and position of the horns on the head are characteristic of each group of the bovids: round in cross-section and lateral in position in the cattle; slender, recurved or twisted, somewhat compressed or sharply keeled in most antelopes; heavy, cross-ridged, triangular in section and often spiral in sheep and goats; more or less flattened, angulated, inclining upward and backwards, with an inward curve toward the tip, and located below the plane of the rear of the skull in the Old World, or "true", buffaloes; smooth, rounded, and closely approximated at the base where they

are depressed and rugose, curving downward and then upward and forward in the muskoxen; and so on.

Apparently arising in the Old World toward the end of the Miocene from the more primitive tragulids—a group represented today by the chevrotains—and characterized by the absence of a caniniform premolar, the bovids became the most numerous and most successful ungulates of late Miocene to Recent times. "Eurasia appears to have been the major center of dispersal of the bovids, and literally dozens of genera have been described from the Old World Pliocene. . . . By the Pleistocene most of them had disappeared from Europe; but in this case, as in many others, Africa and Southern Asia have been havens of refuge for forms which increasing cold had forced from the north temperate region; Africa alone contains some twenty genera of living antelopes" (Romer).

Comparatively few bovids succeeded in reaching North America from Asia and none has entered South America. Only those few forms that were able to endure the cold climate of the Ice Age (Pleistocene) such as the bison, mountain sheep, the so-called "Mountain goat", and muskoxen, reached what is now the United States and were able to maintain themselves here. True oxen of the genus *Bos* never lived here until man introduced domestic cattle, some of which escaping from captivity gave rise to the feral, or "wild", cattle once numerous over our western plains as well as in South America.

The absence of bovine forms, other than *Bison,* from North America has been widely noted, hence it is a matter of much interest that recently there has been found in the Pleistocene of Cass County, Nebraska, a species called *Platycerabos dodsoni* Barbour and Schultz. This genus, while close to various Asiatic bovines, is yet distinct from *Bos,* which includes the domestic cattle; *Bibos,* the gayal of India; *Poëphagus,* the yak which, however, occurs in the Pleistocene of Alaska; *Bubalus,* or water-buffalo; and *Bison.* The horn-cores and the shape of the rear part of the skull preclude any relationship of *Platycerabos* to the muskox (*Ovibos*); while the flatness of the horn-cores is the most distinctive character of the Nebraskan genus, there is yet in this a slight suggestion of the oriental water-buffalo, or *Bubalus.* No such find has as yet been made in Kansas, but it is one of the possibilities of the future.

The genus *Bison,* closely related to true cattle, is still very sparingly represented in Europe, but in North America, it not only

successfully maintained itself for a long time, but even became diversified into a number of species, some of which in the Pleistocene were individually very numerous. Although mainly found in the Great Plains region, they occurred more or less commonly from the Atlantic to the Pacific, and from Alberta to Mexico. In this country (United States) they formed two fairly well defined subgenera known respectively as *Bison* and *Superbison* (Frick). However, the group as a whole is so variable and the distinctive characteristics are often so vague and overlapping that it is usually very difficult to assign a given specimen definitely to its proper species. Detailed study of thousands of specimens, now fortunately under way, is necessary to bring order out of the chaos in which the group stands today. Until such a time as such a study shall have been successfully completed, specific identifications of many of the fossil forms must necessarily be tentative. No attempt can be made here to straighten out the taxonomy of this group, and so we shall merely record the species that have been listed from Kansas by various authors.

Figure 9. Bison bison. Photograph by the K. U. Photographic Bureau of a group in Dyche Museum of Natural History, University of Kansas.

The widely known species of *Bison* that formerly lived in Kansas in vast herds of innumerable individuals must now be regarded as extinct in this state. This species (*Bison bison*), perhaps the smallest of its genus, is popularly miscalled the "Buffalo", though it should be designated as the American, or Plains, Bison. Of this

species four subspecies have been recognized. Of these, that known as the Eastern or Pennsylvanian Bison (*Bison bison pennsylvanicus*) was larger and darker than the Plains form and once lived in the forested region of Pennsylvania northward to Lakes Erie and Ontaria, but the last individual was killed by man about the year 1800. Of the Plains Bison there are, or were, two distinct subspecies, northern and southern forms constituting the two corresponding herds. "By a curious coincidence, the Union Pacific Railroad followed the previously established line between the two herds" (Scott). The southern subspecies is the well-known *Bison bison bison,* while the northern is that first recognized by J. D. Figgins and by him called *Bison bison septemtrionalis.* The fourth subspecies is the Woodland Bison (*Bison bison athabascae*), a somewhat larger and darker form, similar to the Pennsylvanian race, now reduced to a single herd of a few hundred head maintained and protected in Athabasca, Canada.

The Plains Bison (Fig. 9), fortunately, as the result of man's recent attempts at its protection, still is represented by several thousand individuals in national, state or private parks or preserves. The bull of this subspecies is decidedly larger than the cow, reaching a total length of about eleven feet, of which the tail accounts for about two feet; a height at the shoulders a little under six feet; with an average weight of around 1800 pounds, though exceptionally large individuals may exceed 2200 pounds. The cows are only about seven feet long, including a tail of a foot and a half in length; a height of five feet at the shoulders; and a weight varying between 800 and 1200 pounds.

Fossil remains of *Bison bison* have been found in Cherokee, Cheyenne, Douglas, Leavenworth and Logan Counties, and doubtfully identified from Atchison, Clark, Coffey, Harvey, Labette, McPherson, Norton and Wilson Counties. It is doubtful whether there is a single county among the whole 105 in Kansas in which its remains may not be expected to occur.

In 1905, Dr. C. E. McClung described a fragmentary bison skull which had been washed out of the bank of the Kaw (Kansas) River, in North Lawrence, Douglas County. He considered it to represent a new species which he called *Bison kansensis* (see: Trans. Kans. Acad. Sci., vol. 19, p. 157, fig. 10). It has also been recorded from Finney County. This form is very similar to another species usually referred to as *Bison occidentalis* (for which see below) and possibly belongs to that form. Another skull, more complete, was found the

same year by L. D. Read about 3 miles northeast of North Lawrence and about 1½ miles north of the Kaw River, where it had apparently been carried by the record-breaking flood of 1903. The dimensions of this skull also accord with those of *Bison occidentalis.*

A somewhat larger species, *Bison alleni,* was described by O. C. Marsh, of Yale University, in 1877 (Amer. Journ. Sci., ser, 3, vol. 4, p. 252), and was based on a horn-core found in the Big Blue River, near Manhattan, Riley County. This specimen was purchased by Dr. S. W. Williston from the finder (see: Trans. Kans. Acad. Sci., vol. 15, p. 92, 1898). This species has also been listed from Wellington, Sumner County, on the basis of a skull which Cope described in 1894 (Proc. Acad. Nat. Sci. Phila., p. 68; and Journ., same academy, vol. 9, p. 456), as *Bos* (now *Bison*) *crampianus.* This skull is in the museum of the Academy of Natural Sciences in Philadelphia, but is now assigned to Marsh's species, *B. alleni.*

In this connection it may be of interest to note that the best specimens of *Bison alleni* have come from Alaska. One of these, now in the United States National Museum, from Little Munook Creek, a few miles southeast of Rampart, Alaska, is of especial value since it still retains the horn-sheaths in place on the cores. But by far the most complete specimen is from Hunter Creek just below the mouth of Dawson Creek, about six miles southeast of Rampart, and consists of the skull, mandible and five cervical vertebrae. In

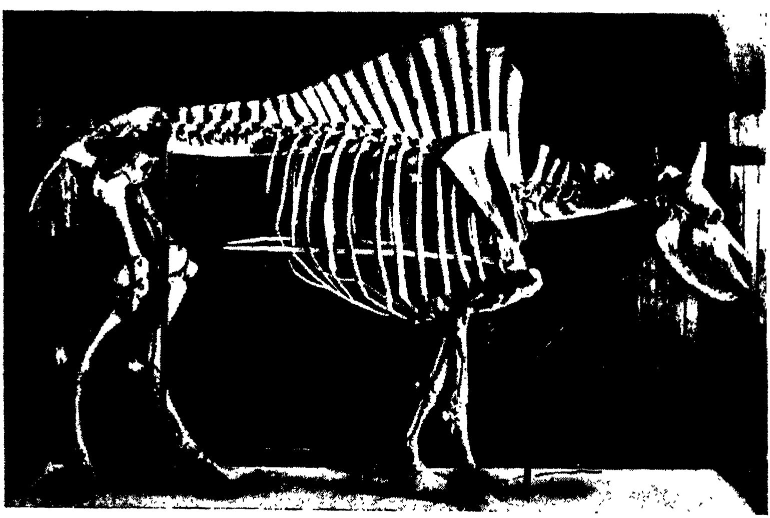

Figure 10. Bison occidentalis, fossil bison. Photograph of skeleton by the late H. T. Martin who collected and mounted it.

both these specimens the horn-cores are rather long, slender, and uniformly curved, directed outward, upward, and somewhat backward, and finally strongly inward. The facial region of the skull is rather narrow, more so than in *Bison occidentalis.*

The University of Kansas Museum has two specimens of *Bison alleni,* one (KUMVP, No. 4927) from Wilson County, while the other (KUMVP, No. 4634) is from near Newton, Harvey County.

The type of *Bison occidentalis* (U. S. Nat. Mus., No. 4157) was discovered by Sir John Richardson at Fort Yukon, Alaska. It consists of the rear part of a skull bearing the two horn-cores. A nearly complete skull referred to this species, found in the Fox Gulch mine, near Dawson, Yukon Territory, is in the American Museum of Natural History in New York City (Amer. Mus., No. 13721). As the type of *Bison occidentalis* consists only of the horn-cores, frontals and occipital, a question must attach to the characters of the dentition. The referred specimen has the skull characters of the type and adds the additional one of the presence of an external pillar on the third molar. This character is so markedly at variance to its nearly total absence in other races of *Bison* that Figgins has proposed its assignment to a new genus which he calls *Stelabison,* with *B. occidentalis* as the type, which thus becomes *Stelabison occidentalis.*

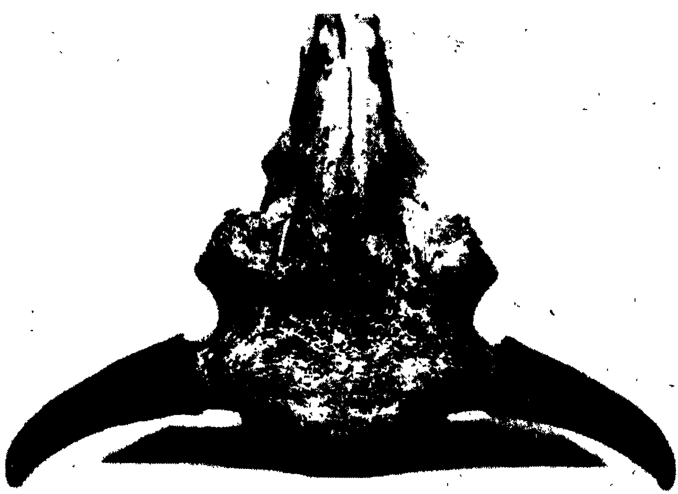

Figure 11. Skull of Bison occidentalis. Photograph by the late H. T. Martin. Same skull in side view on Fig. 10. Specimen in KUMVP.

This species has been recorded (as *Bison occidentalis*) from Douglas, Ellis, Logan and McPherson Counties. A fine mounted specimen (Figs. 10 and 11), probably of this species but originally described by Alban Stewart under the name of *Bison antiquus* and later referred by Lucas and McClung to *Bison occidentalis,* is in the Natural History Museum of the University of Kansas. It was collected by the late H. T. Martin in Logan County on Twelve Mile Creek, about half a mile north of the Smoky Hill River, 12 miles east of Russell Springs. It was one of five skeletons, all apparently members of one herd, buried beneath 25 feet of soil and fully 12 feet straight back into the bank. Aside from its very large size, exceeding the living *Bison bison* in all its dimensions, this specimen is of especial interest because when exhumed there was found a stone arrow-point lying in the matrix beneath the right shoulder blade, against which the artifact had been pressed so that it had produced a raised place on the opposite surface of the bone. This was the first instance of the discovery of a human artifact in indubitable association with the remains of an extinct species of bison, but despite the fact that this association was vouched for by Martin, Williston and McClung, it was long received with incredulity by archeologists. This record stood alone for about 25 years. However, the last twenty years have seen the discovery of more than two dozen such finds in New Mexico, Texas, Oklahoma and Colorado, notably by the late J. D. Figgins and his staff, then of the Colorado Museum of Natural History, all in connection with extinct species of bison, so that it is no longer possible to doubt that man lived in Kansas and elsewhere in North America during the late Pleistocene and hunted several species of bison for meat and hides, among them *Bison occidentalis, Bison alleni,* and others.

On the basis of details in tooth structure, Figgins has recognized two additional subspecies of *Stelabison occidentalis,* which he calls *S. o. francisci* and *S. o. taylori* respectively. The skeleton in the K. U. museum may belong to the subspecies *toylori.*

The largest as well as the least known of North American bisons is that called *Bison latifrons* (Fig. 12), which was described over a century ago by Harlan. The type is a pair of magnificent horn-cores found in Adams County, Ohio, and now in the museum of the State Historical Society at Cincinnati, Ohio. Not over a dozen other specimens—all fragmentary—have been discovered. One of these was found in September, 1925, by Mr. James O'Connel, the owner of a large cattle ranch twenty-five miles southeast of Coldwater, Com-

Figure 12. Bison latifrons and Bison regius (?). Restoration by Bernard Frazer in a diorama in the KUMVP.

anche County, Kansas, and by him presented to the late H. T. Martin. It is now in the University of Kansas Museum of Natural History (KUMVP, No. 201). As noted by Martin: "When found this specimen was embedded in a layer of loose, sandy Pleistocene gravel, about fifteen feet above the present bed of [Cottonwood Creek, in Section 6, Township 35, Range 17 west, Comanche County, Kansas, 1½ miles north of the Kansas-Oklahoma state line], and directly on top of the red beds, where a shallow, basin-like depression had been formed by the previous action of the creek during high-water freshets. Into this depression the head and horn-cores had been washed, settled to the bottom, and had been buried in the sedimentary deposits of the stream, . . . The Coldwater specimen is by no means complete, yet there are sufficient skull parts present to supply . . . measurements of the ventral surface of the preoccipital region as well as of the upper part of the skull from the occipital crest to the level of the frontonasal sutures. . . . One noticeable feature of *Bison latifrons* is the great thickness of the horn-cores, together with the intricate network of longitudinal and transverse pillars in the interior of the cores at the base; these result in greater strength for the support of the massive horns which this animal carried." Martin estimated "that the distance from tip to tip of the horn-cores was originally not less than 6 feet 8 inches", which would indicate that when the sheaths were in place on the living animal, the total spread of the horns was probably between nine and ten feet. The width of the skull between the bases of the horn-cores is 15

inches. Certainly *Bison latifrons* was a gigantic beast.

A partial skull with horn-cores collected by John Newsom, of Scott City, Scott County, Kansas, is in the museum of the University of Nebraska at Lincoln (Univ. Nebr. State Mus., No. 20261). This specimen came from gravels which are believed by Schultz and Frankforter to be equivalent to the Long Island of Nebraska, *i.e.*, probably of late Kansan or early Yarmouth age.

O. P. Hay (Proc. U. S. Nat. Mus., vol. 46, p. 192) described another species of *Superbison* as *Bison regius,* basing it upon a fine skull now in the American Museum of Natural History, New York (No. 14346). Hay notes that this skull was found "in the vicinity of Hoxie, Sheridan County, Kansas, in 1902, on Sand Creek, a stream which empties into the Solomon River. The Missouri Pacific Railroad cut a new channel for the creek and in so doing came near the skull; afterwards a freshet washed away some of the bank and exposed it. It is said to have been buried at a depth of 35 feet. . . . It is most probable that it belongs to the early or middle of the Pleistocene."

Unfortunately no indubitable specimen of *Bison latifrons* yet found has any teeth in association with the skull. Many years ago Leidy described and figured five large molar teeth of a bison, which, from their size, he regarded as those of *B. latifrons.* They had been found near Natchez, Mississippi, in association with remains of mastodon, horse, bear, deer, megalonyx, mylodon and a large extinct cat. Hay compares these teeth with those of *B. regius* and finds them quite different. Accepting Leidy's identification, Hay decides that the type of *Bison regius* cannot be a specimen of *Bison latifrons,* and on this doubtful foundation erects his species. However, Hay acknowledges the possibility "that the large teeth described by Leidy do not belong to *Bison latifrons*", but if they do, then, he says, "B. *latifrons* and *B. regius,* among American Bisons, stand at the extremes of the complication of the enamel in the walls of the cement lakes". This certainly cannot be said to be indubitable evidence of the specific distinctness of *B. regius* from *B. latifrons* because of the questionable standing of the teeth Leidy referred to the latter species.

Another point to which the late H. T. Martin called my attention years ago is considered by Hay who "was at first strongly inclined to regard this skull [Amer. Mus., No. 14346] as having belonged to the female of *Bison latifrons.*" In the present-day *Bison bison,* "the females . . . have, often at least, horn-cores slenderer and more strongly curved than those of the males. If the horn-cores

of the two sexes of *Bison latifrons* varied in the same way, the fine pair in Cincinnati might be regarded as those of a bull; while the skull here described [from Kansas] might be looked upon as that of a cow. . . . If comparisons are made between the measurements . . . of *B. latifrons* found in Ohio and the corresponding measurements of *B. regius,* it will be seen that *B. latifrons* has the forehead wider by 20 to 45 mm.; that the horn-cores are of slightly greater diameter, but are somewhat shorter, and that they are far less strongly curved." Hence, Hay "admits that it is possible that these differences may be due to individual, racial, or sexual variation. In the last named case [*i.e.,* sexual] the Ohio animal might represent the male; the Kansas specimen the female." To the present writer, this conclusion seems most probable, though the matter can never be definitely settled until the find of an indubitable *Bison latifrons* skull with the molar teeth in place. So, tentatively and with considerable doubt, Hays' *Bison regius* is here listed among the fossil bisons of Kansas (Fig. 12).

In 1924 the late H. T. Martin (K. U. Sci. Bull., vol. 15, no. 6, pp. 273-283, pls. XXVI and XXVII, Dec., 1924) described a new species of bison from the Middle Pleistocene, south side of the Arkansas River, near Garden City, Finney County, Kansas, and named it *Bison willistoni* (KUMVP, type, No. 390). The specimen consists of a perfect left horn-core and a small part of the left maxillary with a part of the last upper molar. It was found at a depth of seven or eight feet below the level of the surrounding prairie in a sandy gravel cemented together by carbonate of lime. Associated with it were the bones and teeth of *Mammuthus primigenius* and a horse very close to *Equus excelsus.* The fragment of the bison maxilla indicates thicker walls and a much more heavily built skull than hitherto described, and represents an animal much larger and more robust than *B. occidentalis,* which is probably its nearest relative. *B. willistoni* belongs to the group comprising *B. occidentalis, B. kansensis,* and *B. bison,* but is distinguished from any of these forms by the greater circumference of the horn-core and the more sharply upward curve of its distal fourth. The base of the horn-core of *B. willistoni* does not sag, but, instead, rises in a gentle curve from the level of the skull for about three-fourths of its length, from which point it curves sharply to its tip, which terminates more obtusely than does that of *B. occidentalis.*

In comparison with specimens of *B. occidentalis, B. kansensis* and *B. bison* in the K. U. museum, *B. willistoni* is greater in all

its dimenisons than any of the other three. Especially noteworthy is the greater vertical flattening of the horn-core of *B. willistoni* along its whole length than in the case of *B. occidentalis*, the distal third of the latter being cylindrical in shape. In tooth characters also all three species are very distinct from one another.

Family Bovidae: Subfamily Ovibovinae:

Figure 13. Muskox. Photograph from life at College, Alaska by L. J. Palmer. Used by permission of the U. S. Fish and Wildlife Service, Washington, D. C.

The living genus of muskox, *Ovibos* (Fig. 13), now confined to the arctic regions of North America and Greenland, was widely distributed over this continent at various times in the Pleistocene "Ice Age". Fossil remains belonging to the living species (*Ovibos moschatus*) have been found in New Jersey, Pennsylvania, Ohio, Indiana, Minnesota, South Dakota, Iowa, Nebraska, Oklahoma, Colorado, Ontario, Alberta, and Alaska. There can be no doubt, therefore, that it lived in Kansas, though no actual remains have as yet been found in this state. Identical or closely related forms in the Pleistocene occurred also over a large part of Siberia and westward to Germany, France, and Great Britain. It is now confined to the Barren Grounds east of the Mackenzie River valley, the arctic islands north of Hudson Bay, and a narrow coastal strip on both sides of northern Greenland, but everywhere is diminishing fast in numbers. It is more exclusively arctic than the Reindeer or Caribou,

inhabiting the remote, treeless tundras of the far North where vegetation is scanty and the ground is buried under snow for most of the year.

Though sometimes looked upon as a sort of "connecting link" between oxen and sheep, the Muskoxen are in reality not closely related to either of these groups, despite the fact that the generic name of the living form (*Ovibos*) means literally "sheep-ox". The dental formula is: I-0/4 C-0/0 P-3/3 M-3/3=32.

Covered with a heavy fleece of long, soft hair and wool, both sexes are alike in coloration, having the upper parts black or brownish-black, except for a lighter brown "saddle" on the back behind the shoulders; nose and feet white. The males are larger than the females, reaching a total length of eight feet, of which the tail claims only four inches; four and a half to nearly five feet high at the shoulders. They are highly gregarious.

Their most striking feature, perhaps, is found in the horns, which in the males have broad bases which nearly meet over the middle of the skull to form a broad casque over the brow and the whole crown of the head. Each horn at first turns downward along the side of the face and then curves upward and forward to end about on the level of the eye in a black-pointed tip. The horns are smaller in the females and young males. The limbs are short and stout and end in asymmetrical hoofs, the outer one being rounded, while the inner one is pointed, and the sole of the foot is more or less covered with hair.

Remains of fossil muskoxen in Kansas are rare. The first recorded specimen from this state was found somewhere near Wilson, Ellsworth County, and was sent to Cope by Jacob Fowler in 1877; it is now in the American Museum of Natural History (No. 12699). This is a rather large skull, though badly damaged, since the facial portion is missing and both horn-cores are broken off close to the skull. It is unquestionably referred to *Symbos cavifrons* (Leidy), the type of which was found near Fort Gibson, Oklahoma, and was first described by Leidy as *Boötherium cavifrons,* but later removed to the genus *Symbos.* This type specimen has an unusual history since "it was found in the hut of an Indian, to whom it served as a seat".

Mr. George Sternberg has in his museum at Fort Hays State College, the base of another muskox skull (?*Symbos*) found many years ago in the vicinity of Fort Hays, but with no record of locality or horizon.

A third specimen was found by Dr. Thad McLaughlin of the United States Geological Survey, in Grant County, Kansas. It came from the Sullivan pit in the SW¼ of Section 7, Township 29 South, Range 37 West, and is in the University of Kansas Museum (No. 6686). It is referred by Dr. R. A. Stirton, of the University of California, Berkeley, to the genus *Euceratherium*. Little is known of this genus. It occurs in cave deposits in California and elsewhere. It is of great interest since it has "affinities to the muskoxen on the one hand, and on the other to sheep and certain antelopes, such as the Takin (*Budorcas*) of India and Tibet, and thus tends to connect the problematical muskoxen with other Cavicornia [hollow-horned ruminants] and indicates central Asia as the probable place of origin" (Scott).

The bases of the horns in *Symbos* meet and unite in the mid-line of the skull to form a complete shield of horn-covered bone; the horns themselves, however, are smaller than in the living musk-oxen. This genus has been found from Alaska to Arkansas, and its distribution indicates that it shifted its range with the climatic changes that accompanied the advance or retreat of the great ice-caps of the Pleistocene.

Order Perissodactyla:

The last order of mammals represented by fossil remains from Kansas is that called the *Perissodactyla*. This was a dominant group in North America from early to mid-Tertiary times but underwent

Figure 14. Eohoppus monticolus. Photograph by the K. U. Photographic Bureau of a diorama by Bernard Frazer in the KUMVP.

a more or less rapid decline in the late Tertiary and finally became extinct on this continent in the Pleistocene. At the present time this order includes but three families, namely, the horses (*Equidae*), the rhinoceroses (*Rhinocerotidae*) and the tapirs (*Tapiridae*), although it formerly included nine or ten others now extinct. Today only the tapirs are found in Central and South America, while North America is entirely without indigenous members of this order—the domestic horse and ass being recent importations from the Old World.

The three living families of perissodactyls superficially appear so unlike that their kinship is obscured. But when their paleontological history is reviewed, it is seen that they—as well as the extinct families—had a common origin in or near the Lower Eocene, their members then being structurally very similar. In fact they seem to have arisen from one or another of the thirteen known species of *Eohippus* (Fig 14). However, they early showed a tendency to follow several different lines of specialization, some of which proved inadequate and soon came to an end, while the three now living not only pursued divergent paths, but, in the case of the horses and the rhinoceroses, followed a complex course of development, producing a great variety of genera and species. Much, if not most, of this history in these two families was made here in North America.

The perissodactyls all have the cheek-teeth in a continuous series, possessing large to very large, triangular to quadrangular, transversely ridged crowns, the pattern of which, especially in the horses, becomes very complex in the later species. All but the first premolars tend to become molariform, especially in the case of the posterior ones which are often like the molars in size and structure. The outer incisors are sometimes developed into large tusks, notably so in the rhinoceroses, or they may be effective cropping chisels. The dorso-lumbar vertebrae are usually 23 in number, never less than 22. The third, or middle digit on each foot is larger than the others carrying most or all the weight of the body, and ends in a rounded phalanx covered by a hoof. In the horses this is the only functional toe; in the tapirs and rhinoceroses the second and fourth toes also may be fairly well developed, while in the tapirs and several extinct forms, the fifth toe remains on the front feet. In all cases, however, the axis of the foot passes along the *third* toe—hence, the term *mesaxonic* applied to them. This is in contrast to the artiodactyls in which the axis of the foot passes *between* the third and fourth toes—hence, there termed *paraxonic*. The stomach is always simple and the caecum large and capacious. The gall-bladder is always

absent. The milk glands are inguinal in position and the placenta is diffused. (In the artiodactyls the placenta is diffused or cotyledonary.)

In the perissodactyls the cheek-teeth have a crown-pattern consisting of three *lophs* (i.e., ridges), an antero-posterior outer ridge and two transverse ridges extending toward the inner side of the tooth, thus primarily forming the Greek letter π. The earlier members of this order, with their short-crowned (*brachyodont*) teeth show this original plan of crown-pattern most clearly, but in the later horses, where the teeth are extremely *hypsodont* (i.e., long crowned and rootless) this primitive pattern is obscured by infoldings of the enamel so that it is not clearly apparent without careful inspection.

Apparently already in the Paleocene the Perissodactyla had diverged into two well-defined suborders, termed respectively the Chelopoda, and the Ancylopoda. The Chelopoda in turn may be divided into two sections, the *Hippomorpha* and the *Ceratomorpha*. Of the living perissodactyls, the horses belong to the first of these two sections, while the tapirs and rhinoceroses are located in the second. Altogether twelve families of perissodactyls have been recognized, the evolutionary development of which constitutes very interesting and, in some cases, very extensive chapters in vertebrate paleontology. However, Kansas presents us with only the later or even the last paragraphs in but two of these chapters, namely, that of the horses and the rhinoceroses. For, of the three living families of perissodactyls, the tapirs do not find a place in the Kansas records, nor in fact have they been found in any part of the Great Plains region except near El Paso, Texas, and the report by Troxell of a "fossil tapir", not otherwise described, from near Mulhall, Logan County, Oklahome. This absence of tapirs from the Great Plains region is undoubtedly due to the fact that they have always been restricted to densely forested regions, and today live in the heavy tropical forests of Central and South America, and one species in the Dutch East Indies. They have always been a very conservative group and, except for the late development of a short proboscis, the living species differ little from their Oligocene relatives. If any group deserves the appellation of "living fossils", this is one.

The second family of perissodactyls comprising living as well as extinct genera and species is that of the *Rhinocerotidae*. Of this family, Kansas has been credited with five genera and seven species.

Some of these, however, are synonyms, so that probably but three genera and four species are valid.

Like several other families of fossil ungulates found in Kansas, that of the rhinoceroses is badly in need of critical study and revision. Many species have been described by Leidy, Cope, Marsh, Osborn, Hatcher, Matthew, Cook, Wood and others, who are often in disagreement in their recognition not only of species but even of genera. This is not the place nor is the present author able to throw light on this situation. Hence, I shall merely list the most generally recognized species that have been recorded from Kansas.

The three most generally accepted genera of rhinoceroses from the Miocene and Pliocene of North America are:

(1) *Peraceras,* with a broad, short skull, wide at the base behind, no upper incisors, a full set (four) of premolars, and short-crowned molars.

(2) *Teleoceras,* with a broad, skull of medium length, moderately broad at the base behind, with strong upper incisors, large lower tusks curving upward, premolars reduced in number, molars very long crowned, and a short mandibular symphysis.

(3) *Aphelops,* with a long, narrow skull, narrow and high behind; full set of premolars, molars short-crowned, upper incisors weak or absent, lower tusks heavy and somewhat procumbent, and a long mandibular symphysis.

To these may be added (4) *Paraphelops,* skull unknown but certainly very long and narrow, with a narrow occipital portion, upper incisors well-developed, lower tusks erect, not procumbent, lower premolars reduced to two, molars short-crowned, and the mandibular symphysis very long.

Peraceras superciliosus Cope and *P. troxelli* Matthews are listed by Cook and Cook from the "Republican River Formation of Nebraska and Kansas", but without more definite citation of locality data. I know of no actual record of this genus from Kansas.

Three species of *Teleoceros,* namely *T. fossiger* (Cope), *T. crassus* (Leidy), and *T. major* Hatcher are listed by Cook and Cook from the "Republican River Formation of Nebraska and Kansas", again without definite locality data. I find no other record of *T. crassus* from Kansas, while *T. major* is probably only a large male of *T. fossiger*. *Teleoceros fossiger,* on the other hand, is very common in the famous Long Island Quarry, Phillips County, Kansas, a deposit of Lower Pliocene or possibly Upper Miocene age. It is generally referred to the Republican River formation. This quarry

has yielded the remains of hundreds of individuals of this species. At least four mounted skeletons of *T. fossiger* from this area are to be seen in as many museums, the oldest of which (Fig 15) is that in the University of Kansas Museum of Vertebrate Paleontology.

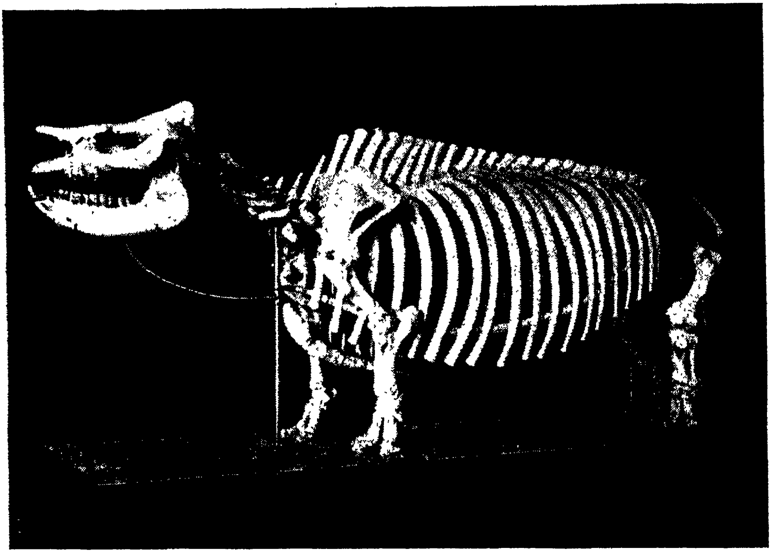

Figure 15. Teleoceras, a fossil rhinoceros. Photograph of a mounted skeleton in the KUMVP by the late Dr. S. W. Williston.*

This deposit was discovered by the late Charles H. Sternberg who found that the rhinoceros bones lie on the bottom layer of sand two feet in thickness; the heavy short bones of the feet and legs lie at the very bottom, while the skulls, pelvic and pectoral arches, and vertebrae are above, a situation that Sternberg interpreted as indicating that the animals were trapped in quicksand.

Teleoceros differs from the other genera of rhinoceroses found in Kansas in that it is very short-legged, big bodied, and the males have a short horn on the tip of the nasals. It may have been aquatic or at least semi-equatic in habit. In all probability an immigrant from Asia, *Teleoceros* became the most common and widespread rhinoceros in the Upper Miocene and Lower Pliocene of North America, reaching even to Florida; at the same time they were numerous also in Asia. While only about four feet high at the shoulder it was ten feet long and its body in form and size sug-

***All photographs of exhibits in Dyche Museum were secured through the kind cooperation of Mr. Russell Camp of the Museum staff.**

gests a hogshead or other very large barrel. Its daily consumption of food must have been enormous. It had a brain that was large for a rhinoceros. What caused its extinction in North America is not known, unless it was due to increasing aridity throughout its range; it would appear to have been as well fitted to survive as its modern kin. Its remains in Kansas are as abundant as those of horses or bison.

Marsh, in 1887, described as *Aceratherium acutum,* a rhinoceros skull and mandible from the "Upper Miocene", Long Island, Phillips County, which is in the Yale University museum. This is probably more correctly identified as *Teleoceros fossiger.*

The genus *Aphelops* was hornless, with the lateral lower incisors developed into large procumbent tusks; there were no upper tusks. The skull in different species of this genus varied from medium to very long, and the cheek-teeth were brachyodont or short-crowned to almost hypsodont. The legs were rather long, much longer than those of *Teleoceros.* In size this genus was about equal to or somewhat larger than the oriental rhinoceroses living today. That it may have been very abundant in the Middle Pliocene of Kansas is indicated by the find of remains of at least twenty-one individuals at Rhino Hill, Sherman County, by the University of Kansas field party. The species found there is listed by Hibbard as *Aphelops* cf. *mutilus* Matthew. It is from the Edson beds, Ogallala formation, Middle Pliocene.

Another species was described many years ago by Cope as *Aphelops malacorhinus,* the type of which (Amer. Mus., Cope Coll., No. 8381) came from Sappa Creek, Decatur County, Kansas, probably Lower Pliocene.

The last genus of rhinoceros (*Paraphelops*) from Kansas was described by the present author and is represented by a mandible (KUMVP, No. 2913) of a large individual, very likely an old male, from the Republican River deposit near Plainville, Rooks County, Upper Miocene or Lower Pliocene. It was obtained from a gravel pit, and was donated to the museum of the University of Kansas by Mr. Roy Dial, of Topeka. The total length of the mandible from the anterior margin of the symphysis to the posterior border of the ascending ramus, projected upon a plane surface, is 603 mm., only slightly less than that of large specimens of the living White Rhinoceros of South Africa—thus representing a much larger form than *Teleoceros* or *Aphelops.* The median lower incisors are absent; the lateral lower incisors have the form of a pair of

large, curved, erect tusks; the lower canines are wanting as are also the first and second premolars. The type species is *Paraphelops rooksensis* Lane. A second species of *Paraphelops* has been described by Harold J. Cook from north-eastern Colorado.

The Kansas specimen of *Paraphelops* is of further interest since it has wedged between the roots of the fourth premolar and the first molar of the left side a large pebble which could not be pried out without breaking the roots of these teeth. This pebble must have become wedged in place when the animal was still alive and the roots of the teeth were elastic enough to permit its admission between them. That this pebble caused much pain to the animal is shown by the necrotic condition of the jaw bone and the loss of some of the bone tissue about the roots of these teeth; there is thus the clear indication of the occurrence of an abscess on the jaw.

Family Equidae:

The last family of the Perissodactyla to be considered in this survey is that of the horses, which reach the highest degree of specialization to be found in this order. By far the greater part of the paleontological history of the horses is recorded in the Eocene to Pleistocene formations of North America, and relatively few of the numerous genera reached other continents. The family starts in the Lower Eocene with little *Eohippus* (Fig. 14), of which thirteen species are known, varying in height from ten to fifteen inches at the shoulders, and all with four toes (in some cases with the vestige of the thumb also) on the front feet and three on the hind. Their teeth were short-crowned with a simple pattern on the upper molars consisting of six main cusps partly elongated to form three ridges (*lophs*)—an outer one parallel to the fore-and-aft axis of the tooth, and two transverse ridges, one anterior and one posterior, hence forming a pattern suggestive of the Greek letter π, which is the ground pattern of all the primitive perissodactyls and is still characteristic of the rhinoceroses. Succeeding *Eohippus* there is a series of nine later genera, beginning with *Orohippus* in the Middle Eocene and running in an unbroken line to *Equus*, the modern horse, of the Pleistocene and Recent. The principal changes seen in this series of genera include a gradual increase in body size, an increase in size and complexity of crown-pattern in the cheek-teeth, involving a gradual transition from very small short-crowned to very large long-crowned premolars and molars, and the gradual reduction in the number of toes from three to one on each foot. Numerous other correlated changes in the skeleton also occurred, including the

development of a very long face, and very deep jaws to accommodate the lengthy series of very long cheek-teeth. Reduction in the number of teeth has been very slight, in fact, about ten to twelve per cent of individual living horses still retain the original number of 44, though stallions may have but 40 and most mares now have but 36.

Merychippus, the most ancient genus of horse yet recorded from Kansas, is the seventh in the direct line of ten genera from *Eohippus* to *Equus*—the modern horse—inclusive. *Merychippus* appeared first in the Middle Miocene of North America and persisted as a very common form in the Late Miocene. It includes altogether some twenty-five recognized species, mostly from various parts of the Great Plains region, which were decidedly variable in the characters of the teeth and skeleton. From first to last there was a rapid elongation of the cheek-teeth (premolars and molars). In the earliest species the upper molars were relatively short-crowned, being only about as high as wide. The milk-teeth were disproportionately short-crowned and had an archaic crown-pattern, hardly different from that of the still older ancestral genus, *Parahippus,* of the Lower Miocene. A heavy coat of cement (=*tartar*) was formed over the teeth at a late stage in their individual development. The production of high-crowned (*hypsodont*) teeth was undoubtedly correlated with a change of diet from the softer vegetation eaten by the earlier browsing horses to that consisting mainly of hard siliceous grasses, which made their appearance in the Miocene. Short-crowned teeth (*brachyodont*) would not have lasted long under the abrasive action of the hard grasses of the plains where *Merychippus* and its descendants lived.

While many species of *Merychippus* were small, some equalled a donkey in size. Its feet were three-toed, but longer than in preceding forms, *e.g.*, its direct ancestor, *Parahippus,* but the side toes were hardly more than "dew-claws"; it walked on the tip of its toes like a modern horse. It ranged from Florida, Texas and California, northward to Montana and Oregon. It made its last appearance in the Republican River beds of Nebraska and Kansas. There is but one record from Kansas—and that a doubtful one. This is a single tooth found by Dr. E. R. Hall on an Indian camp site four miles north of Atchison, Atchison County. It was identified by O. P. Hay as *Protohippus* and very possibly correctly so, for the two genera are very similar and hard to distinguish from one another.

Protohippus, Hipparion and *Pliohippus* are three genera ap-

parently all direct offspring of *Merychippus.* They comprise a large number of species that exhibit a considerable range of variation in body size and in the characters of their cheek-teeth. They all differ from *Merychippus* in having the permanent cheek-teeth with longer crowns than those in the latter genus but shorter than those in *Equus* of the Pleistocene and Recent. Their milk-teeth were longer than those of *Merychippus* and were well supplied with cement.

Protohippus, about 40 inches high at the shoulders (the size of the average Shetland pony), from the Lower Pliocene, was a slightly more advanced genus than its parent form (*Merychippus*), but it led away from the main line of equine descent. Many of the changes first noted in *Merychippus* were carried further in *Protohippus;* the molar crowns, for example, were almost twice as high as those of the older genus. The feet, of moderate length, were three-toed, though the middle digit carried all the weight on *hard* ground; on *soft* ground the side toes were probably of service to prevent the foot from sinking too deep. The terminal phalanx of the middle toe (*third*) was in shape much like that of the modern horse, though somewhat thinner and flatter. The orbit of the eye was completely encircled by bone—a condition here reached for the first time in the horses—and the facial portion of the skull was elongated to accommodate the longer row of cheek-teeth. *Protohippus,* first recognized by Leidy, differs from the contemporary genus, *Hipparion,* primarily in the connection of the internal pillar (*protocone*) of the cheek-teeth with the anterior crescent through an isthmus or commissure. In cross-section the protocone has the shape of a "wooden-shoe"—in this respect resembling *Pliohippus.* *Protohippus* has not yet been recorded from Kansas, unless the Atchison specimen referred to above under *Merychippus* really represents it.

Hipparion is sometimes characterized as "the classic horse of the Pliocene of both the Old and New World" (Matthew and Stirton). A dozen or more valid species have been recorded, about three-fourths of them from North America. Here the most advanced species of *Merychippus* grade into the most primitive species of *Hipparion,* so that the separation of these two genera at that point can only be made arbitrarily by definition, since the teeth at one stage of wear may be typical of one genus and at another stage, of the second genus. In all species of *Hipparion* the feet retained the complete side toes, *i.e.,* were tri-dactyl, although the middle toes were much the largest; the hoofs were more slender even than those of a

mule. The different species varied in size from that of a gazelle to that of an ass.

The most distinctive characteristic of *Hipparion* is the presence of an independent pillar (*protocone*) on the inner side of the cheek-teeth. In other horses this pillar is connected to the anterior crescent of the crown of the tooth by an isthmus or commissure throughout its whole length. The crown-pattern otherwise varies from a relatively simple one like that of *Merychippus* to one even more complex than that of the later horses (*Equus*). In some the inner pillar (*protocone*) is circular in cross-section, like that of *Merychippus*, while in others it is broad and flat as in modern horses. Gidley separated the latter type from *Hipparion sensu stricto* and called it *Neohipparion*, in which the limbs and feet are exceptionally long, but with the side toes much reduced, or possibly even absent in the most progressive species.

Hipparion is recorded by Hibbard from the Edson beds, Ogallala formation, Middle Pliocene, of Sherman County, as *Hipparion* cf. *montezumae* (Leidy), and *Hipparion cragini* Hay, from the Thomas Ranch, Clark County.

Considered as a subgenus of *Hipparion* by some, but raised to full generic rank by others is *Calippus*, a group of small, slender species with very long-crowned teeth in which the inner pillar (*protocone*) is partly or wholly connected with the anterior crescent of the tooth by a narrow isthmus at its anterior end. *Calippus ansae* Matthew and Stirton is recorded by Hibbard from the Edson beds, Middle Pliocene, of Sherman County.

Another group related to *Hipparion* has been distinguished as *Nannippus*; this form has very long-crowned cheek-teeth, some even exceeding by one fourth the teeth of living horses. The protocone is oval in cross-section, and the feet and legs are extremely slender. This was a small, pony-like animal (*Nannippus*="dwarf horse") in which the side toes were still complete. Hibbard records *Nannippus phlegon* (Hay) from the Rexroad fauna, Blancan formation, of Meade County, Kansas.

Pliohippus, of the Lower and Middle Pliocene, was the eighth stage in the direct line from *Eohippus* to the modern *Equus*. Like *Protohippus* and *Hipparion*, it too was the direct offspring of *Merychippus*, having been derived from a group of merychippine species which included *Merychippus campestris* and its allies. *Pliohippus* was somewhat larger than the Miocene horses, and had longer crowned, *curved* cheek-teeth, which in some instances were as much

as three times as high as wide. This genus is at first difficult to separate from *Merychippus,* for here again progression in many characters was slow and uneven, and intergradations were numerous. In typical individuals, not only the permanent cheek-teeth, but even more distinctively, its milk-teeth also were much higher crowned than in *Merychippus,* being once and a half to twice as high, and quite heavily coated with cement. The skull of *Pliohippus* is disproportionally large in comparison with the rest of the skeleton. The legs and feet also were more robust and heavier than those of *Merychippus,* although the lateral toes were progressively reduced to exceedingly slender vestiges, which in some species seem to have been mere splints, so that *Pliohippus* eventually became as *monodactyl* as the modern horse. The several species varied in size from that of an ass to that of a broncho.

A species named *Pliohippus nobilis* by Osborn was based on the type specimen in the American Museum of Natural History "from the Middle (?) Pliocene of Kansas". Hibbard records *Pliohippus* cf. *pernix* Marsh from the Edson beds, Middle Pliocene, of Sherman County, Kansas.

The ninth stage in the direct line of equine descent in North America is represented by the genus *Plesippus* from the Upper Pliocene of Texas to California and northward to Idaho. In the last named state, near Hagerman, parties from the United States National Museum collected in four seasons of work "over 130 skulls and a large quantity of other skeletal material", with the greater part of the skeleton in 8 or 10 specimens. The cheek-teeth have a pattern much like that of the later species of *Pliohippus* but with longer, more nearly straight crowns. The feet are very much like those of *Equus,* being completely monodactyl, with the splints representing the second and fourth digits somewhat less reduced than in modern horses. Other changes in the skeleton were numerous and mostly all in the same direction, *i.e.,* toward the true horses. *Plesippus* was still larger than *Pliohippus,* nearly equaling the domestic horse in size. It was thus, as the name indicates, "almost a horse", for the skeleton is completely modernized and indicates a heavier animal than any of its predecessors, which were light and slenderer in build.

One species, *Plesippus* cf. *simplicidens,* has been recorded by Hibbard from the Upper Pliocene, Emma Creek formation, of McPherson County, as well as from the Rexroad fauna, Blancan formation, of Meade County, Kansas. Gazin thinks that the Hager-

man fauna of Idaho is also Blancan in age.

The tenth stage in the direct line of horse development was attained in the genus *Equus,* which ranges in time from the base of the Pleistocene to Recent. This genus apparently arose directly from *Plesippus* and appeared in both Europe and North America at very nearly the same time. The earliest species are nearer *Plesippus* in tooth structure and crown-pattern than are the living horses.

The genus *Equus* attained an almost world-wide distribution by the latter Pleistocene, for its fossil remains have been found in all parts of both North and South America, except in the glaciated regions of the former continent, as well as over Europe and Asia, and in Africa from the Mediterranean coast to Natal. It was absent only from Australia and oceanic islands until introduced there by man in a domesticated state. Among the living horses there are a number of species more or less closely related. "The living zebras and asses, although different in color pattern, size, and proportions, are so close to the domestic horse in skeleton that it is very difficult to distinguish their fossil remains. Some of the extinct species of *Equus* are thought to be especially related in teeth to the zebra, others are more certainly related to the ass; but the three types are not clearly distinct among the Pleistocene species" (Matthew and Stirton).

"The Pleistocene horses of North America all belonged to the genus Equus. These Pleistocene species were numerous and varied, ranging in size from a Shetland pony (*E. tau*) to animals exceeding the largest modern draught-horses (*E. giganteus*), but most of them were of moderate height, 14 to 15 hands, and some examples of *E. occidentalis,* of California, retained the slender, deer-like legs of the ancestral three-toed genera" (Scott).

For some unsatisfactorily explained reason, the close of the Pleistocene saw the extinction of all horses in both North and South America. The immediate ancestry of all existing species lived in the Old World, not only of our domestic horses and asses, but also of the *feral* types once so numerous on our Great Plains and the pampas of South America, which were the descendants of the Spanish horses brought to America by the conquistadores, such as Coronado, in Kansas, for example.

"In the existing members of this family the dental and skeletal characteristics are more uniform than might be inferred from external appearances. Color-pattern, character of mane and tail, length of ears make horses, asses, zebras and quaggas look very different,

but such characters are not registered in the skeleton. At the present time, true horses (*Equus przewalskii*) exist in the wild state only in central Asia. . . . Wild asses occur in Asia and Africa, and the striped equines, zebras and quaggas, are exclusively African" (Scott).

The horses are the most progressive of all perissodactyls, and yet they show very little or no reduction in the number of the teeth. The incisors are chisel-shaped cropping teeth in a closed series, each with an enamel-lined pit (the "mark"), found in the teeth of no other animal. Behind them is a long diastema in which lies, in the male, the small canine. Though not intended by nature for such use, man could not have employed a bitted bridle by which to manage his steed, were it not for the presence of this diastema, into which the bit is introduced. The six functional cheek-teeth on either side above and below are very high crowned (*hypsodont*) and continue to grow in length as worn away by use, until very old age, when roots develop and growth stops. The very complicated crown-pattern is made up of alternating areas of dentine, enamel and cement, which, wearing away at different rates, produce a most efficient mill-stone-like apparatus for grinding the hard grasses that constitute most of the horses' food. The facial portion of the skull is greatly elongated and the jaws much deepened to accommodate the long rows of grinding teeth. The premolars, except the first, in size and crown-pattern are very much like the molars. But in limb structure, the horses are the most highly specialized of all perissodactyls, being almost perfectly adapted for speedy locomotion over hard ground, and restricted almost wholly to motion fore and aft. For mechanical reasons, in adaptation to rapid running, the humerus and femur are short, powerful bones that swing through a short arc, driven by powerful muscles, while suspended from them are the much longer lower segments of the limbs and feet. This is an ideal arrangement to produce a long stride and quick movement over the ground. Correlated with this has come a great reduction in certain elements such as the ulna and fibula, which remain only as vestiges grown fast to the radius and tibia respectively. Correlated changes in the wrist (*carpus*) and ankle (*tarsus*), and the loss of the lateral digits, have resulted in a loss of limb rotation, but have produced a great increase in the strength and usefulness of the limbs in running.

A half dozen or more species of *Equus* have been recorded from the Pleistocene deposits of Kansas. Aside from size differences, these are all based largely upon variations in the crown-pattern of

the premolars and molars, and are too difficult to describe in words. Without typical specimens in hand for comparison, it is often very hard even for experts to assign a specimen definitely to its proper species. We shall therefore content ourselves with a mere list of names of these species with references to the localities in which they are known to occur. They are all from the Pleistocene.

Equus francisci Hay is recorded from Harvey County; *Equus leidyi,* from Harvey, McPherson, and Clark Counties; *Equus niobrarensis,* probably the most common species of all, from Doniphan, Harvey, Lane, Lincoln, Meade and McPherson Counties; *Equus complicatus,* from McPherson, Marshall, Meade and Ottawa Counties; *Equus* cf. *excelsus,* from Finney and Lane Counties; and *Equus laurentius,* from Douglas and Logan Counties. Undetermined species are recorded from Comanche, Harvey, and Russell Counties. In fact, one or more of these or other species may be expected to occur in almost every Pleistocene deposit throughout the whole state of Kansas.

With the preceding account of the mammals the author brings to a conclusion this Survey of the Fossil Vertebrates of Kansas. While every possible effort has been made to include all forms hitherto recorded in the literature, doubtless some have been inadvertently overlooked. The author would therefore take it as a great favor that, if any of his readers know of such omissions, they would send him a separate or, if that be not possible, give him the exact time and place of publication of such records.

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The Flora of Douglas County, Kansas

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Introduction

This study of the flora in Douglas County, Kansas, was made with two objectives in mind. The first was to compile as complete a list as possible of the ferns and flowering plants that occur in the county and to support this list with specimens filed in the Herbarium at the University of Kansas. The second objective was to study the individual species in the environment in which they grow and to record this information.

Previous work on this subject was first accomplished by Prof. James H. Carruth of the University of Kansas. He published several papers in the Trans. of the Kans. Acad. of Science from 1872 to 1889, listing the plants of Kansas and where they had been collected. Carruth (Centennial Catalogue of the Plants of Kansas, Trans. Kans. Acad. of Science, 5:40-59, 1877) listed 748 species of ferns and flowering plants for Douglas County.

Since Carruth, several individuals have reported plants from the county. Among these may be mentioned Hitchcock (Flora of Kansas Maps, 1899) and Paul B. Lawson (The Grasses of Douglas County, Trans. Kans. Acad. of Science, 30:336-339, 1922). The most recent list of plants for the county was included in the Flora of Kansas by F. C. Gates, published in 1940. He listed about 650 species of ferns and flowering plants for the county, based on plants in the herbaria of Kansas State College, University of Kansas, and Kansas State Teachers College at Emporia.

Location and Size of Douglas County

Douglas County consists of an area of 299,520 acres located in the southeast portion of the northeast quarter of the State of Kansas. It is bordered on the north by Jefferson and Leavenworth counties, on the east by Johnson County, on the south by Franklin County, and by Osage and Shawnee counties on the west. It is the sixth smallest county in the State.

Topography[1]

Douglas County is traversed by two principal streams, the Kansas or Kaw River and Wakarusa Creek, both of which run in a general west to east direction. The Kansas River is the larger of

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[1]See Fig. I, to accompany discussion of topography.

the two and forms the north boundary of the county except for some eighteen square miles located on the north side of the river, north of the city of Lawrence. This area is for the most part river bottom land except for the northern edge and northeast quarter which consist of rolling hills. In this bottom are located several small semi-permanent swampy areas found in the old river channel. The soil of the river bottom along the Kansas River is sandy loam.

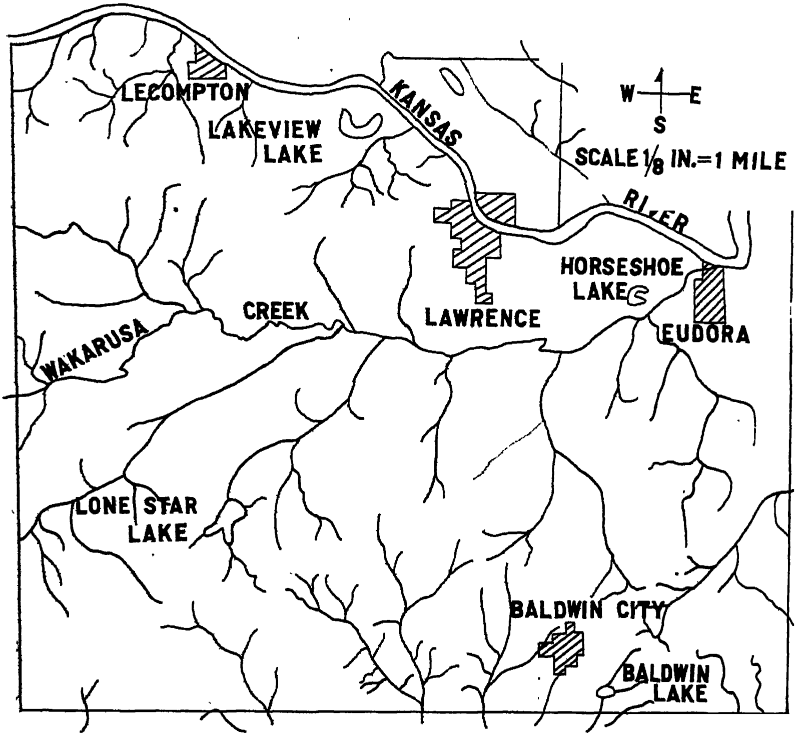

Fig. 1 PHYSIOGRAPHIC MAP OF DOUGLAS COUNTY

Along that part of the Kansas River forming the west third of the north county line is a rather narrow strip of river bottom which in some places is only a hundred yards, and never more than a half mile, wide. In the vicinity of Lakeview Lake, which is an old oxbow lake formed by the Kansas River, is found a considerable amount of river bottom land. About half-way from Lakeview to the city of Lawrence the river cuts back to the south bluff and then veers away leaving a strip of river bottom land a quarter to a half mile wide which extends on into the city. East of the city of Lawrence, the river bottom becomes gradually wider until it merges with the

Wakarusa Creek valley about two miles east of the city limits. At this point the bottom land formed by the union of the two river valleys is some four and one-half miles wide. The Wakarusa, however, runs northeast at this point and as the south bank of the Wakarusa is formed by hills, the river bottom steadily becomes narrower until the Wakarusa runs into the Kansas River at the northeast edge of the Eudora city limits.

Wakarusa Creek enters the county at the west central edge. It runs northeast for the first quarter of its passage through the county and extends some three miles north in doing so. At this point it veers generally eastward, running for some thirteen miles to the point where it again shifts northeast to join the Kansas River near the northeastern corner of the county. Though the Wakarusa is normally a small stream, it does have a rather wide valley. Shortly after it enters the county, the creek valley becomes nearly a mile wide and maintains that width except for numerous places where it becomes a half to one mile wider until it merges with the Kansas River valley. The soil in the Wakarusa Creek valley is for the most part heavy gumbo. Where the valley merges with that of the Kansas River, the soil becomes steadily more sandy.

Located about half way between the entrance of Wakarusa Creek into the county and the point where the Kansas River touches the northwest edge of the county is a ridge which runs in a slight southeasterly direction to a point two miles east of Lawrence. North of this ridge the land slopes to the Kansas River and many small creeks run in a general northerly direction to the river. This causes the land to be rather rough and hilly due to the numerous small creek valleys. South of the ridge several more creeks run in a general south to southeasterly direction to the Wakarusa, and again the terrain is rough, hilly and rolling. South of the Wakarusa are many small creeks which run in a north to northeast direction to the Wakarusa, again dissecting the terrain and causing rolling, rather rough hilly land.

Starting at a point about three miles north of the southwest corner of the county and running generally northeast to a point about six miles north of the south central point of the county, and then running generally southeast to a point about three miles north of the southeast corner of the county, is a region which drains south into the Marais de Cygne River. This river runs from west to east through Franklin County which is to the south.

From the preceding discussion it can be easily ascertained that

the topography of Douglas County is anything but level. The nearest approach to level upland comes in the south third of the county, particularly in the western part of this region.

As mentioned before, the soil along the Kansas River consists of sandy loam and that of Wakarusa Creek, of heavy gumbo. In the hills of the extreme northeast corner of the county, north of the Kansas River and along the eastern edge and the southeast fourth of the county, is found a considerable amount of sandy soil and sandstone rock outcroppings. The rest of the county is, in general covered by loam soils with limestone rock outcroppings. In some places the top soil has been eroded leaving clay soils exposed. Many road cuts leave clay banks exposed.

In the county is a rather large artificial lake located in the southwest quarter. Another much smaller artificial lake is located in the southeast quarter. One oxbow lake appears in the Wakarusa valley, and one large and a few small ones appear in the Kansas River valley. Farm ponds are numerous throughout the county.

Climate

The climate of the county is one of its most variable features. Sudden changes in temperature, wind and precipitation are common. Temperature extremes vary from —18° to 108° F. with the averages being rather moderate. The average precipitation is about 34.6 inches per year. The distribution of rainfall over a growing season is often very unsatisfactory to vegetation. The periods of heaviest rainfall come in fall and spring. Blizzards and ice storms are not unknown and often cause damage to vegetation. Snowfall is moderate and snow seldom remains for long on the ground.

Original Vegetation

The original vegetation of Douglas County consisted mostly of typical prairie plants. The only wooded areas were found on some of the hillsides and along the streams. The plants making up the original vegetation might be found most accurately by studying the list of Kansas plants as prepared by Carruth (1877). So far as he was able, he distinguished between native plants and immigrants.

Following a study of Carruth's list, one is impressed by the fact that our common prairie plants now are the same as they were shortly after the county was settled. Also, his list of native trees corresponds with the common trees of our present woodlands. Many of the plants recorded by Carruth have not been found since this time. This is probably due in part to his misidentifications.

The abundance of many plants found in the county now is much less than in the original vegetation. Several species recorded by other observers, and for which specimens are on file in various Herbaria, have not been found in this survey. However, it is not to be supposed that such plants are no longer to be found in the county.

Present Vegetation

When the native prairie of the county was plowed and put under cultivation, a profound change occurred in the flora of the region. The native flora was pushed to out of the way places such as roadsides, fence rows, railroad right of ways, rocky hillsides and waste lands.

With the coming of the white man to the region came a host of plants not native to the region. Carruth (1877) reported about forty-one species of plants not native to Kansas as occurring in the state, principally around Lawrence, in Douglas County. New plants have invaded the county as time passed, and are still coming in. Such plants occupy large areas of the region.

Though the prairie has been for the most part destroyed, the woodlands have increased in extent. Thus most of the rough hillsides and streambanks are wooded, and in undisturbed conditions the wooded areas are increasing in size.

As might be gathered from the above discussion, there is a great diversity of plant groupings in the county ranging from life on open water to that of the prairie, woodlands and dry rocky cliffs. The following plant groupings are typical and representative of the plant communities in Douglas County.

Prairie. The prairie which once covered the most of Douglas County is now confined to a few hay meadows, some pasture and to a few relics along railroad right of ways and roadsides. The nearest approach to undisturbed prairie comes in these relics and in a few waste places around native prairie hay meadows.

In general, the prairie can be divided into two types. The first and more common type is the upland prairie. This upland or dry prairie is found on level upland, hilltops and hillsides. The second type is the lowland or wet prairie found in stream valleys, particularly in the Wakarusa Creek valley.

The dominant plants of the upland prairie consist of a few species of tall grasses. *Andropogon scoparius,* or little bluestem, is the most frequent grass on the uplands where growing conditions are less favorable. *Andropogon provincialis,* (*Andropogon furcatus*) or big bluestem, follows little bluestem in importance and occurs

most frequently where growing conditions are more favorable. Following the bluestems, but of much less importance, are several other grasses, namely: *Bouteloua curtipendula, Sporobolus heterolepis, Koeleria gracilis, Sorghastrum nutans* and *Panicum virgatum.* These seldom make up more than a small percentage of the upland prairie flora.

In the upland prairie a number of characteristic species are found and can be listed as spring, summer and fall aspects. In the spring aspect several species may be found. They very seldom make up an appreciable amount of the upland prairie flora and for the most part are evident because of their coloration and because they do, in some species, outgrow and mature before the grasses have started growth. The more important of these plants are *Baptisia leucophaea, Lithospermum linearifolium, Sisyrinchium campestre, Phlox pilosa, Tradescantia bracteata, Geoprumnon crassicarpum, Erigeron annuus, Senecio plattensis, Nothoscordium bivalve, Viola pedatifida* and *Camassia esculenta.*

The summer aspect of the upland prairie is not as colorful as the spring aspect. Grasses have undergone considerable growth, thus allowing less room for other plants. Some of the more common plants found are species of *Silphium, Petalostemon, Echinacea, Psoralidium, Rosa, Erigeron, Rudbeckia, Linum, Salvia* and *Lespedeza.*

In the fall the upland prairie in undisturbed conditions is covered with the tall grasses in which are dispersed scattered individuals or colonies of plants which are largely composites. The most common of these are species of *Solidago, Aster, Liatris, Artemisia, Kuhnia* and *Helianthus.*

The lowland prairie differs from the upland prairie in the abundance of the tall-grass species and in the secondary species. *Andropogon provincialis* is dominant over all other grasses, and little bluestem is absent or, at the most, present to a very limited extent. *Sorghastrum nutans* is quite common in the lowland prairie type. In very wet prairie *Spartina pectinata* may be the dominant grass, and in such cases *Panicum virgatum* will be found abundant in the area.

For the most part, the spring aspect of the lowland prairie is little different from that of the upland prairie. Certain of the characteristic species are more plentiful in the lowland prairie type and weeds have a greater tendency to appear. Common plants to be found are *Antennaria campestris, Hypoxis hirsuta, Nothoscordium bivalve, Viola papilionacea, Phlox pilosa, Baptisia leucophaea,*

Tradescantia bracteata, Galium tinctorium, Carex spp., and *Allium mutabile.*

The summer aspect is quite different in the lowland prairie from that in the upland type. Generally the grasses are rank in growth, therefore crowding out most plants which might grow there. Among the plants more commonly found are *Thalictrum dasycarpum, Melanthium virginicum, Zizia aurea, Pleiotaenia nuttallii,* and *Lilium canadense.*

In the fall the lowland prairie in undisturbed conditions consists of the rank dominant grasses and a few scattered composites, chiefly species of *Solidago, Helianthus, Vernonia* and *Aster.* None of the lowland prairies in the county has been observed to reach a typical undisturbed fall condition because of the prairies having been mown for hay. The observations made consisted of the study of fence row remanants, certain small regions around the head of draws and other regions not reached by the mowing machine.

Woodlands. The woodlands of Douglas County consist of three types. The first type, and the one which is the most advanced woodland in the region, is the oak-hickory association. The second type consists of the mixed woodlands, and the third is the willow-cottonwood association.

The oak-hickory association is the most common type of woodland and occupies the more or less undisturbed hill-top and hill-side wooded regions of the area. The dominant tree of this association is *Quercus muhlenbergii.* Other dominants are *Quercus macrocarpa, Quercus velutina, Carya ovata, Carya cordiformis, Ulmus americana, Celtis occidentalis* and *Ostrya virginiana.* Common shrubs consist of the ever present *Symphoricarpos orbiculatus* and, to a much less degree, *Aesculus glabra, Staphylea trifoliata, Asimina triloba, Svida asperifolia* and *Rhamnus lanceolata.* Of the many smaller plants to be found in this association are *Podophyllum peltatum, Viola* spp., *Phlox divaricata, Isopyrum biternatum, Ranunculus* spp., *Geum* spp., *Carex* spp., *Mesadenia atriplicifolia, Eupatorium* spp., *Aster* spp., *Solidago* spp., *Galium* spp., *Stachys tenuifolia, Ruellia strepens, Scrophularia marilandica,* and several species of grasses.

The dominants of the oak-hickory association vary somewhat according to the type of soil on which the trees grow. Dry hill tops consist mainly of *Quercus muhlenbergii* and *Q. velutina.* Sandy hillsides consist of *Q. muhlenbergii, Q. marilandica* and *Q. stellata.* In some strictly sandy soils of hillsides *Q. marilandica* is the domi-

nant tree. The secondary species also vary with the soil types except that *Symphoricarpos orbiculatus* is always present and is the dominant undergrowth.

Mixed woodland types are to be found in areas which have been cut over and burned and along the small streams and tributaries. This is also the pioneer type of woodland and is slowly replaced by the oak-hickory association in undisturbed areas. The dominant tree of the mixed woodland is most certainly *Ulmus americana.* Along with this elm are found *Ulmus fulva, Fraxinus lanceolata, Acer negundo, Acer saccharinum, Platanus occidentalis, Juglans nigra, Tilia americana* and *Celtis occidentalis.* The secondary species are the same as for the oak-hickory association except that the species either occur in greater abundance or a greater number of species occur in small quantities. *Symphoricarpos orbiculatus* is again the most common and abundant of the shrubs.

In many places along the Kansas River are to be found woodlands consisting of willow and cottonwood. In some places solid stands of either or both of these trees occur. The cottonwoods often attain a good size, but we notice that willows of any size occur sporadically and usually do so in a more mixed type of woods. In many places the willows occur in numbers so great as to exclude other vegetation; but where they do so, they seldom reach a height of more than fifteen feet. In many places the cottonwoods and willows grow along with *Ulmus americana, Fraxinus lanceolata, Platanus occidentalis* and *Acer saccharinum;* but when such is the case, the woodland is above normal floodplain levels.

The dominant trees are *Populus virginiana, Salix interior, Salix nigra* and *Salix amygdaloides.* The secondary species vary from year to year or from flood to flood, but usually consist of large colonies of *Polygonum* spp., *Persicaria* spp., *Carex* spp., and many other plants which occur in greater or lesser numbers.

Roadside Plants. A complete list of plants found along the roads in the county would nearly duplicate the list of plants to be found in the whole county. Roadside vegetation consists of the border plants of whatever plant community the road passes. In many places the roadside plants of any certain plant community form the last remains of that community for the particular region.

When a critical study of roadside vegetation is made, it is found that the majority of plants consist of typical dry meadow species. This is probably due to the similarity of soil and light conditions. Therefore, most of the roads are bordered by vegetation

of the upland prairie which includes the dominant species and exhibits the seasonal aspects of the secondary species. Many roads in the Wakarusa Creek valley are bordered by lowland prairie and again the dominant species of that prairie type are to be found. Roads through wooded areas are of course bordered by trees, but the woodland secondary species are found more abundant next to the road.

Thickets are found commonly on roadside banks. Where thickets occur, they commonly consist of nearly solid growths of the species concerned. Plants making up the various thickets are *Svida asperifolia, Prunus americana, Maclura pomifera, Malus ioensis, Rhus glabra, Rhus copallina, Corylus americana, Rhus trilobata, Rosa* spp., *Rubus* spp., and *Symphoricarpos orbiculatus.*

The roadsides form convenient avenues of escape for many plants growing under cultivation. Many of these persist for only a season but some are able to maintain themselves indefinitely. A few of the plants which have escaped to the roadside and have maintained their existence are species of *Melilotus, Lespedeza, Hemerocallis, Ornithogalum, Asparagus, Saponaria*, and *Delphinium.*

Just as the roadside forms an avenue of escape for cultivated plants, it also is the means of plants being introduced into a region from other places. Cattle trucks passing along the highways on their way to the cattle market afford good possibilities for dispersal of seed along the route. It is not uncommon to find colonies of plants from western parts of the state springing up along the highway. Most persist for only a season. However, it is undoubtedly true that several of these have persisted in the past and more will do so in the future, thus increasing the local flora and increasing the range of species involved.

Pastures. In Douglas County there are approximately 96,295 acres of land devoted to pasture. Of this, about 94,905 acres are in tame grass and the remaining 1,390 acres consist of native prairie. The flora of these pastures is directly correlated with the degree to which the land is pastured. In the tame grass pastures overgrazing allows such plants as *Maclura, Symphoricarpos, Rhus* and many smaller plants to come in and dominate the area. Among the most common of these smaller plants are species of *Verbena, Vernonia, Cirsium, Achillea, Boebera, Amphiachyris, Ambrosia, Plantago, Datura, Solanum, Lithospermum, Croton, Cheirinia, Sophia* and *Lepidium.*

For the most part prairie pastures are composed of typical dry

prairie plants. However, when these pastures become overgrazed certain plants, particularly of the family *Carduaceae,* begin to take over. The most common of these plants are species of *Solidago, Aster, Erigeron* and *Artemisia.* If overgrazing continues the pasture soon takes on the appearance of the severely overgrazed tame grass pasture.

Cultivated Fields. Cultivated fields are invaded by a host of plants commonly referred to as weeds. Most of these are annuals and occur in such large numbers or in such close proximity with the cultivated crop that they can't all be destroyed; therefore, a plentiful seed supply for the ensuing year is nearly always assured. The most common plants, and those which are most abundant, are species of *Helianthus, Xanthium, Amaranthus, Chenopodium, Convolvulus, Cuscuta, Ipomoea, Abutilon, Agrostemma, Thlaspi, Lactuca, Polygonum,* and several species of grasses.

Abandoned Fields. A few tilled fields in Douglas County have been abandoned and left idle due to the top soil having been washed away. Many such fields are found in Jefferson County to the north of Douglas County. The soil remaining on these fields is hardpan clay. The dominant plant found on such fields is *Aristida oligantha.* In the fall of the year abandoned fields show up white with the dried remains of this grass. In addition to *Aristida,* other grasses found are species of *Agrostis, Bromus, Eragrostis, Digitaria, Festuca* and *Panicum.* In addition to these grasses are found other plants such as species of *Artemisia, Helianthus* and *Xanthium.*

Sandbars and Floodplains. Sandbars and floodplains are limited to a few places along the Kansas River. The dominant plants of these regions are growths of willow and cottonwood which often are so thick as to exclude other plants. The most common willows are *Salix interior* and *Salix nigra,* while the cottonwood is *Populus virginiana.* In addition to these plants a whole host of different plants come up after each flood only to be washed away during the next high water. During dry seasons the flora of the sandbar and floodplain is quite luxuriant and diverse. The most common of these plants are species of *Persicaria, Polygonum, Xanthium, Carex, Cyperus* and several species of grasses. The floodplain differs from the sandbar in that the vegetation is more stable. In addition to willows and cottonwoods are found elm, ash and occasionally sycamore. The grasses and sedges form a more stable society while various species of composites may or may not exist according to the season.

Streambanks. The streambanks and the banks of small tributaries are wooded unless continued cutting destroys them. The most common trees are elm, ash, boxelder, soft maple, sycamore, cottonwood and willow. Floods eliminate shrubs from the regions of the banks most frequently flooded, but higher up are found *Symphoricarpos* and *Sambucus*. The other vegetation found along streambanks is composed of a variety of plants which have been washed in from surrounding fields. It is not unusual to find most any plant of a region appearing along streambanks. In the stream bed itself or on the banks are found ***Dianthera***, species of *Cyperus, Carex, Polygonum, Persicaria, Penthorum, Cannabis, Urtica, Alisma, Ilysanthes* and several grasses.

Lake and Pond Shores. The shores of the lakes and ponds of the county are for the most part wooded. Willow, cottonwood, elm, ash and soft maple are the most common trees found, though around some of the artificial lakes and ponds are found oaks, hickory, walnut and a few other trees, depending upon the habitat in which the lake was formed. In the shallow water and in muddy places around lakes are found *Cephalanthus, Hibiscus, Typha, Alisma, Sagittaria, Sparganium, Potamogeton, Echinodorus, Heteranthera* and *Lemna*. Farther away from the water are found species of *Carex, Cyperus, Persicaria, Polygonum, Potentilla, Ranunculus*, and several species of grasses. The flora around many of the artificial ponds is the same as that of the surrounding area except for a few feet around the water's edge. The natural lakes are restricted to one oxbow lake in the Wakarusa Creek valley and a few of the same type in the Kansas River valley. Most of the latter, however, are more nearly swamps than lakes.

Swamps and Seepage Areas. In the Kansas River and Wakarusa Creek valleys are to be found several swampy regions. During normal seasons these areas are covered with shallow water and surrounded by a limited area of wet soil. In many fields and in draws are found seepage areas which are moist and swampy. In the river valley swamps the shallow water is normally quite clogged with species of *Potamogeton* and the surface covered with *Lemna*. A few such places contain large colonies of ***Nelumbo lutea***. Near the edge of the water are found large numbers of ***Sagittaria latifolia***. Next in the succession and most prominent is the inevitable cat-tail *Typha latifolia* and, to a lesser degree, the narrow leaved cat-tail *Typha angustifolia*. To the outside of this association is found a narrow bank of *Scirpus validus*. From the edge of the cat-tails or *Scirpus*

to the edge of the swampy area is to be found a dense growth of *Persicaria* and *Polygonum* spp. Normally the edge of the swamp is fringed with willow and cottonwood. Throughout the swampy region there are found many species of sedges, grasses and various other plants.

Seepage areas differ from the swamps mainly in the absence of the open water plants. The prominent plants are the cat-tail *Typha latifolia, Spartina pectinata,* and several species of grasses and sedges.

Annotated List

The following list includes all the species and varieties of ferns and flowering plants found in this survey. It also includes several species which were not found, but for which specimens are on file from the county in the Herbarium at the University of Kansas. Such records are so designated in the list by the name of the collector placed in parenthesis with the species concerned. Several species are also included on the authority of Gates (1940). In the latter case, species involved are designated by Gates, 1940, being placed in parenthesis after the species concerned.

The families are listed alphabetically, as are the genera and species within the family. The nomenclature follows that of Rydberg (Flora of the Prairies and Plains of Central North America, 1932), except in cases where species were not listed in his manual and where the species are included on the authority of Gates.

Acanthaceae

Dianthera americana L.
Stream banks, swampy places.
Ruellia ciliosa Pursh.
Prairie, thickets, waste places.
Ruellia strepens L.
Woods.

Aceraceae

Acer saccharinum L.
Woods, along streams.
Acer Saccharum Marsh.
Woods.
Negundo nuttallii (Nieuwl.) Rydb.
Woods, along streams.

Alismaceae

Alisma subcordatum Raf.
Common in swampy areas and around ponds and stream banks.
Echinodorus cordifolius (L.) Griseb.
Common in pond borders and swampy areas.
Lophotocarpus calycinus (Engelm.) J. G. Smith. (F. H. Snow).
Sagittaria latifolia Willd.
Common in shallow water of ponds, lakes, slow moving streams, and in swampy areas.
Sagittaria brevirostra Mack. and Bush. (W. H. Saunders, Aug. 30, 1867).

Alliaceae

Allium canadense L.
Prairies, fields and waste places.
Allium mutabile Michx.
Low moist fields and prairie.
Allium nuttallii S. Wats.
Dry prairie.
Allium vineale L.
Low moist prairies and fields.
Androstephium caeruleum (Scheele) Greene.
Dry prairie.
Nothoscordium bivalve (L.) Britton.
Prairies, fields, sandy banks, open woods.

Alsinaceae

Cerastium brachypodum (Engelm.) B. L. Robinson.
Dry sandy soil.
Cerastium nutans Raf.
Woods, fields and waste places.
Cerastium vulgatum L.
Fields and waste places.
Cerastium vulgatum hirsutum Fries. (Gates, 1940)
Sabulina patula (Michx.) Small.
Dry rocky hillsides.
Stellaria media (L.) Cyrill.
Fields and waste places.
Stellaria longifolia Muhl.
Yards and waste places.

Amaranthaceae

Acnida tamariscina (Nutt.) Wood.
Moist sandy banks.
Amaranthus blitoides S. Wats.
Dry fields, roadsides and waste places.
Amaranthus graecizans L.
Fields and waste places.
Amaranthus hybridus L.
Roadsides, fields, waste places.
Amaranthus spinosus L. (Gates, 1940)
Amaranthus torreyi (A. Gray) Benth.
Sandy hillsides and waste places.
Amaranthus retroflexus L.
Fields and waste places.
Froelichia gracilis Moq.
Dry sandy soil.

Amaryllidaceae

Hypoxis hirsuta (L.) Coville.
Prairies.

Ambrosiaceae

Ambrosia coronopifolia T. and G.
Prairies, open wooded hillsides.
Ambrosia elatior L.
Fields, prairie, roadsides, waste places.
Ambrosia trifida L.
Fields, pastures, roadsides, creek banks, waste places.
Iva ciliata Willd.
Low moist places, alluvial soil.
Iva xanthifolia Nutt. (J. H. Oyster, Aug. 28, 1884)
Xanthium globosum Shull. (Gates, 1940)
Xanthium italicum Mor. (Gates, 1940)
Xanthium pennsylvanicum Wallr.
Fields and waste places.

Ammiaceae

Chaerophyllum procumbens (L.) Crantz.
Moist soil, thickets, waste places.
Cicuta maculata L.
Low prairie, woods and thickets.
Cogswellia daucifolia (Nutt.) M. E. Jones.
Prairie.
Cogswellia villosa (Raf.) Schultes.
Thickets and prairie.
Cryptotaenia canadensis (L.) DC.
Woods and waste places.
Daucus carota L.
Fields and waste places.
Daucus pusillus Michx.
Roadsides and waste places.
Eryngium yuccifolium Michx.
Prairie.
Osmorrhiza villicaulis (Fern.) Hydb.
Open wooded hillsides.
Pastinaca sativa L.
Roadsides and waste places.
Pleiotaenia nuttallii (DC.) Coult. and Rose.
Prairie.
Sanicula canadensis L.
Open woods and thickets.
Sanicula marilandica L.
Woods and thickets.
Sium cicutaefolium Omel.
Low moist places.
Spermolepis patens (Nutt.) B. L. Robinson.
Dry sandy soil.
Taenidia integerrima (L.) Drude. (Gates, 1940)
Thaspium barbinode (Michx.) Nutt. (Gates, 1940)
Thaspium trifoliatum flavum Blake. (Gates, 1940)
Torilis anthriscus (L.) Bernh.
Woods, thickets, fields, waste places.
Zizia aurea (L.) Koch.
Prairie, rocky hillsides.

Amygdalaceae

Prunus americana Marsh.
Hillsides and thickets.
Prunus angustifolia Marsh.
Dry hillside thickets.
Prunus hortulana Bailey.
Thickets.
Prunus lanata Mack. and Bush. (Gates, 1940)
Prunus nana DuRoi.
Open woods and thickets.
Prunus persica Batsch.
Roadsides and waste places.
Prunus virginiana L.
Open wooded hillsides and thickets.

Anacardiaceae

Rhus copallina L.
Dry hillsides, roadsides, thickets.

Rhus glabra L.
Dry soil.
Rhus trilobata Nutt.
Thickets, open woods.
Toxicodendron radicans (L.) Kuntze
Thickets, woods, in fence rows.

Anonaceae

Asimina triloba (L.) Dunal.
Woods.

Apocynaceae

Apocynum album Greene.
Fields, roadsides, thickets.
Apocynum cannabinum L.
Fields, prairie.
Apocynum pubescens R.Br.
Roadside, thickets, waste ground.
Apocynum sibiricum Jacq.
Sandbars, thickets.

Araceae

Acorus calamus L.
Ponds and seepage areas. Never found in bloom.
Arisaema triphyllum (L.) Schott.
Moist woods and thickets.
Muricauda dracontium (L.) Small.
Moist woods.

Aristolochiaceae

Asarum reflexum Bicknell.
Rich woods.

Asclepiadaceae

Acerates angustifolia (Nutt.) Dec.
Prairie.
Acerates auriculata Engelm.
Dry rocky hillsides.
Acerates lanuginosa (Nutt.) DC.
Prairie.
Acerates viridiflora (Raf.) Eaton.
Dry sandy soil.
Asclepias amplexicaulis Smith.
Dry sandy soil.
Asclepias incarnata L.
Swampy places.
Asclepias meadii Torr. (W. H. Horr)
Asclepias pulchra Ehrh.
Moist woods.
Asclepias purpurascens L.
Open woods and thickets.
Asclepias speciosa Torr. (Gates, 1940)
Asclepias sullivantii Engelm.
Prairie and thickets.
Asclepias syriaca L.
Prairie, fields, waste places.
Asclepias tuberosa L.
Roadsides, prairie, pastures.
Asclepias verticillata L.
Rocky hillsides, prairie, railroad ballast.
Asclepiodora viridis (Walt.) A. Gray.
Dry soil, pastures, prairie.
Gonolobus laevis Michx.
Fields, woods, thickets, waste places.

Balsaminaceae

Impatiens biflora Walt.
Moist woods.
Impatiens nortonii Rydb.
Moist woods.
Impatiens pallida Nutt.
Woods and creek banks.

Bignoniaceae

Catalpa speciosa Warder.
Roadsides and waste places.
Tecoma radicans (L.) Juss.
Thickets, roadsides.

Boraginaceae

Cynoglossum officinale L.
Pastures and waste ground.
Lappula echinata Gilib. (Gates, 1940)
Lappula occidentalis (S. Wats.) Greene.
Sandy banks and prairie.
Lappula virginiana (L.) Greene.
Woods and thickets.
Lithospermum arvense L.
Fields, pastures, waste places.
Lithospermum canescens (Michx.) Lehm.
Prairie.
Lithospermum gmelini (Michx.) Hitchc.
Rocky hillsides, prairie.
Lithospermum linearifolium Goldie.
Prairie.
Myosotis virginica (L.) B.S.P.
Prairie, rocky wooded hillsides.
Onosmodium occidentale Mackenzie. (F. H. Snow)

Brassicaceae

Alliaria officinalis Andrz.
Woods, thickets.
Arabis canadensis L.
Rocky woody hillsides.
Arabis dentata T. and G.
Streambanks, woods and waste places.
Armoracia rusticana Gaertn.
Escaped around dwellings.
Barbarea vulgaris R.Br.
Fields and waste places.
Brassica campestris L.
Fields and waste places.
Brassica juncea (L.) Cosson.
Fields and waste places.
Brassica kaber (DC.) Wheeler. (Gates, 1940)
Brassica nigra (L.) Koch.
Fields and waste places.
Camelina microcarpa Andrz.
Roadsides and waste places.

Camelina sativa (L.) Crantz. (F. H. Snow)
Capsella bursa-pastoris (L.) Medic.
Yards, fields, waste places.
Cardaria draba (L.) Desv.
Fields and waste places.
Cardamine parviflora L.
Open rocky wooded hillsides.
Cheirinia repanda (L.) Link.
Overgrazed pastures and waste places.
Dentaria laciniata Muhl.
Rich woods.
Descurainia pinnata (Walt.) Britton. (Gates, 1940)
Diplotaxis muralis DC.
Railroad and roadsides.
Draba brachycarpa Nutt.
Dry sandy hills.
Draba reptans (Lam.) Fernald.
Prairies and waste ground.
Draba cuneifolia Nutt.
Prairie and open wooded hillsides.
Erysimum officinale L.
Pastures and waste places.
Iodanthus pinnatifidus (Michx.) Steud. (Gates, 1940)
Lepidium densiflorum Schrad.
Fields, prairie, waste places.
Lepidium virginicum L.
Roadsides, fields, waste places.
Nasturtium officinale R.Br.
Lake shores and swampy places.
Rorippa hispida glabrata Lunell. (Gates, 1940)
Rorippa palustris (L.) Besser.
Low wet places.
Rorippa sessiliflora (Nutt.) Hitchc.
Streambanks and swampy areas.
Rorippa sinuata (Nutt.) Hitchc.
Streambanks, ditches, swampy areas.
Sisymbrium altissimum L.
Fields and waste places.
Sophia intermedia Rydb.
Prairie, roadsides and waste places.
Sophia multifida Gilib.
Waste places.
Thlaspi arvense L.
Fields, roadsides, waste places.

Cactaceae

Opuntia humifusa Raf.
Dry sandy soil.

Caesalpiniaceae

Cassia medsgeri Shafer.
Dry rocky hillsides.
Cercis canadensis L.
Woods.
Chamaecrista fasciculata (Michx.) Greene.
Roadsides, prairie, waste places.
Gleditsia triacanthos L.
Woods, thickets, overgrazed pastures.
Gymnocladus dioica (L.) Koch.
Woods.

Callitrichaceae

Callitriche heterophylla Pursh.
Lake at Lakeview.

Campanulaceae

Campanulastrum americanum (L.) Small.
Woods, thickets, streambanks.
Specularia leptocarpa (Nutt.) A. Gray.
Sandy places, prairie, woods.
Specularia perfoliata (L.) A. DC.
Woods, thickets, prairie, waste places.

Cannabinaceae

Cannabis sativa L.
Streambanks and waste places.
Humulus lupulus L.
Rocky hillsides and thickets.

Capparidaceae

Cleome serrulata Pursh. (Gates, 1940)
Polanisia trachysperma T. and G.
Railroad ballast.

Caprifoliaceae

Sambucus canadensis L.
Thickets, creek banks, roadsides.
Symphoricarpos orbiculatus Moench.
Woods, thickets, pastures, waste places.
Triosteum aurantiacum Bicknell.
Woods and thickets.
Triosteum perfoliatum L.
Open wooded hillsides, thickets, waste places.
Viburnum prunifolium bushii (Ashe.) Palmer and Steyermark. (Gates, 1940)

Carduaceae

Achillea lanulosa Nutt.
Prairie, pastures, roadsides, waste places.
Actinomeris alternifolia (L.) DC.
Woods, thickets.
Amphiachyris dracunculoides (DC.) Nutt.
Prairie, pastures.
Antennaria campestris Rydb.
Prairie.
Antennaria fallax Greene.
Open woods.
Antennaria neglecta Greene, (Gates, 1940)
Antennaria plantaginifolia Hook.
Rocky wooded hillsides.

Arctium minus Schk.
Pastures, waste places.
Artemisia biennis Willd. (Gates, 1940)
Artemisia ludoviciana Nutt.
Prairie, pastures, waste places.
Artemisia lindheimeriana Scheele.
Prairie.
Artemisia vulgaris gnaphalodes (Nutt.) Ktze. (Gates, 1940)
Aster azureus Lindl. (F. H. Snow)
Aster drummondii Lindl.
Prairie and open woodlands.
Aster ericoides L.
Prairie and thickets.
Aster laevis L. (F. H. Snow)
Aster novae-angliae L. (F. H. Snow)
Aster oblongifolius Nutt.
Prairie.
Aster praealtus Poir. (Gates, 1940)
Aster stricticaulis (T. and G.) Rydb.
Low prairie.
Bidens bipinnata L.
Moist woods and thickets.
Bidens frondosa L.
Moist thickets and waste places.
Bidens glaucescens Greene.
Swampy places.
Bidens involucrata (Nutt.) Britton.
Streambanks and swampy areas.
Bidens vulgata Greene.
Woods.
Boebera papposa (Vent.) Rydb.
Prairie, roadsides, waste places.
Boltonia latisquama A. Gray.
Low moist places.
Cirsium altissimum (L.) Spreng.
Pastures, thickets.
Cirsium arvense (L.) Scop. (F. H. Snow)
Cirsium discolor (Muhl.) Spreng.
Rocky hillsides and fields.
Cirsium undulatum (Nutt.) Spreng.
Prairie, pasture.
Coreopsis palmata Nutt.
Prairie, thickets, open woods.
Dracopsis amplexicaulis Vahl.
Low moist places.
Echinacea angustifolia DC.
Prairie.
Echinacea pallida (Nutt.) Britton.
Prairie.
Echinacea paradoxa (Norton) Britton. (Gates, 1940)
Eclipta alba (L.) Hassk. (W. H. Saunders, Sept. 5, 1866)
Erechtites hieracifolia (L.) Raf. (F. H. Snow)
Erigeron annuus (L.) Pers.
Prairie, pastures, fields.
Erigeron philadelphicus L.
Low prairie, thickets, woods.
Erigeron ramosus (Walt.) B.S.P.
Prairie, pastures.
Eupatorium altissimum L.
Rocky hillsides, prairie, thickets.
Eupatorium falcatum Michx. (F. H. Snow)
Eupatorium maculatum L.
Moist woods and thickets.
Eupatorium perfoliatum L.
Streambanks and moist woods.
Eupatorium serotinum Michx.
Prairie, woods, thickets.
Eupatorium urticaefolium Reichard.
Woods.
Euthamia gymnospermoides Greene.
Dry hillsides.
Gnaphalium obtusifolium L.
Open hillsides.
Grindelia squarrosa (Pursh) Dunal.
Prairie and open hillsides.
Helenium autumnale L. (F. H. Snow)
Helenium tenuifolium Nutt.
Rocky wooded hillside.
Helianthus annuus L.
Fields, roadsides, waste places.
Helianthus formosus E. E. Wats. (Gates, 1940)
Helianthus grosseserratus Martens.
Roadsides, prairie.
Helianthus hirsutus Raf.
Dry hillsides.
Helianthus laetiflorus Pers.
Prairie.
Helianthus maximiliani Schrad.
Roadsides, prairie.
Helianthus mollis Lam.
Dry soil.
Helianthus rigidus (Cass.) Desf.
Prairie.
Helianthus salicifolius A. Dietr.
Dry rocky hillsides.
Helianthus severus E. E. Wats.
Rocky hillsides.
Helianthus tuberosus L.
Roadsides, fields, waste places.
Heliopsis scabra Dunal.
Dry soil.
Heterotheca subaxillaris (Lam.) Britton and Rusby.
Dry soil.
Hymenopappus tenuifolius Pursh.
Prairie.
Kuhnia hitchcockii A. Nels.
Prairie.
Kuhnia suaveolens Fresen.
Rocky hillsides, prairie.
Leucanthemum vulgare Lam.
Rocky hillsides, pastures, roadsides.
Lepachys columnifera (Nutt.) Rydb.
Prairie, roadside.
Lepachys pinnata (Vent.) T. and G.
Prairie.

Leptilon canadense (L.) Britton.
Pastures, lawns, waste places.
Leptilon divaricatum (Michx.) Raf.
Roadsides, thickets, waste places.
Liatris angustifolia Bush.
Prairie.
Liatris aspera (Michx.) Greene.
Prairie, roadsides.
Liatris hirsuta Rydb.
Prairie, open wooded hillsides.
Liatris punctata Hook.
Dry hillsides.
Liatris pychnostachya Michx.
Prairie.
Maruta cotula (L.) DC.
Pastures, fields and waste places.
Mesadenia atriplicifolia (L.) Raf.
Open woods.
Mesadenia tuberosa (Nutt.) Britton.
Low moist prairie.
Oligoneuron rigidum (L.) Small.
Roadsides, prairie.
Prionopsis ciliata Nutt. (Gates, 1940)
Rudbeckia hirta L.
Prairie.
Rudbeckia laciniata L.
Moist woods and thickets.
Rudbeckia subtomentosa Pursh.
Roadside, thicket, prairie.
Rudbeckia triloba L.
Prairie, thickets.
Senecio glabellus Poir.
Swampy places.
Senecio obovatus umbratilis Greene.
(Gates, 1940)
Senecio plattensis Nutt.
Low prairie.
Senecio rotundus (Britton) Small.
Low prairie.
Silphium integrifolium Michx.
Low prairie and open wooded hillsides.
Silphium laciniatum L.
Prairie.
Silphium perfoliatum L.
Woods, thickets, prairie.
Silphium speciosum Nutt.
Roadsides, prairie.
Solidago altissima L.
Hillsides, prairie.
Solidago canadensis L.
Thickets, prairie.
Solidago glaberrima Martens.
Roadsides, thickets, prairie.
Solidago moritura Steele.
Prairie, roadsides, thickets.
Solidago nemoralis Ait. (Gates, 1940)
Solidago serotina Ait. (F. H. Snow)
Solidago speciosa angustata T. and G. (Gates, 1940)
Solidago ulmifolia Muhl.
Wooded hillsides, prairie.
Vernonia corymbosa Schwein.
Pasture.
Vernonia fasciculata Michx.
Low prairies, pastures, roadsides.
Vernonia interior Small.
Pastures, roadsides, prairie.

Caryophyllaceae

Agrostemma githago L.
Fields and waste places.
Saponaria officinalis L.
Roadsides and waste places.
Silene antirrhina L.
Roadsides, fields and waste places.
Silene stellata (L.) Ait. f.
Woods and thickets.

Celastraceae

Celastrus scandens L.
Thickets.
Euonymus atropurpureus Jacq.
Woods, thickets.

Ceratophyllaceae

Ceratophyllum demersum L.
Ponds.

Chenopodiaceae

Chenopodium album L.
Fields, waste places and thickets.
Chenopodium ambrosioides L.
Fields and waste places.
Chenopodium berlandieri Moq. (Gates, 1940)
Chenopodium boscianum Moq.
Open woodlands, fields and waste places.
Chenopodium hybridum L.
Woods, thickets and waste places.
Cycloloma atriplicifolium (Spreng.) Coult.
Sandy fields and waste places.
Salsola pestifer A. Nels.
Dry fields and waste places.

Cichoriaceae

Agoseris cuspidata (Pursh) Steud. (Gates, 1940)
Cichorium intybus L.
Roadsides, fields, waste places.
Cymbia occidentalis (Nutt.) Standley.
Prairie.
Hieracium longipilum Torr.
Open woods and prairie.
Hieracium panicualtum L. (F. H. Snow)
Lactuca canadensis L.
Waste places.
Lactuca floridana (L.) Gaertner.
Woods and thickets.
Lactuca ludoviciana (Nutt.) DC.
Fields and waste places.

Lactuca virosa L. (L. A. Curry, Sept. 22, 1915)
Lygodesmia juncea (Pursh.) D. Don.
Prairie.
Nabalus asper (Michx.) T. and G.
Prairie.
Pyrrhopappus carolinianus (Walt.) DC.
Dry soil.
Serinia oppositifolia (Raf.) Kuntze.
Dry sandy soil.
Sonchus asper (L.) All.
Roadsides, fields, waste places.
Taraxacum erythrospermum Andrz.
Lawns, roadsides, waste places.
Taraxacum officinale Weber.
Lawns, roadsides, fields, waste places.
Tragopogon porrifolius L.
Roadsides, fields, waste places.
Tragopogon pratensis L.
Roadsides, waste places.

Cistaceae

Lechea tenuifolia Michx.
Dry hillsides.

Commelinaceae

Commelina virginica L.
Woods, streambanks and damp sandy places.
Tradescantia bracteata Small.
Low prairies.
Tradescantia occidentalis (Britton) Smyth.
Low wet prairies.
Tradescantia reflexa Raf.
Dry prairies and open rocky woods.

Convallariaceae

Asparagus officinalis L.
Waste places.
Polygonatum commutatum (Schultes) Dietr.
Moist woods and thickets.

Convolvulaceae

Convolvulus ambigens House.
Alluvial soil.
Convolvulus arvensis L.
Fields, roadsides, waste places.
Convolvulus interior House.
Sandy soil, thickets, waste places.
Convolvulus sepium L.
Thickets, waste places.
Ipomoea hederacea Jacq.
Fields and waste places.
Ipomoea lacunosa L.
Fields and waste places.
Ipomoea pandurata L.
Dry soil.
Ipomoea purpurea (L.) Roth.
Fields, waste places.

Cornaceae

Svida amomum (Mill.) Small.
Streambanks, moist woods.
Svida asperifolia (Michx.) Small.
Roadsides, woods, thickets.
Svida instolonea A. Nels.
Low moist places and thickets.

Corrigiolaceae

Anychia canadensis (L.) B.S.P.
Open woods and hillsides.

Corylaceae

Corylus americana Walt.
Woods and thickets.
Ostrya virginiana (Mill.) K. Koch.
Woods and thickets.

Cucurbitaceae

Micrampelis lobata (Michx.) Greene.
Railroad right of way.
Pepo foetidissimus (H.B.K.) Britt.
Dry banks, thickets.
Sicyos angulatus L.
Thickets.

Cuscutaceae

Cuscuta campestris Yuncker.
Parasitic on lespedeza, alfalfa.
Cuscuta cephalanthi Engelm.
Parasitic on Cephalanthus, Ulmus, Polygonum.
Cuscuta gronovii Willd.
Parasitic on Polygonum and Composites.
Cuscuta indecora Choisy var. longisepala Yuncker.
Parasitic on Iva ciliata.
Cuscuta paradoxa Raf.
Parasitic on Composites, Persicaria.
Cuscuta polygonorum Engelm.
Parasitic on Polygonum.

Cyperaceae

Carex artitecta Mackenzie. (Gates, 1940)
Carex bicknellii Britton.
Prairies and open woodlands.
Carex blanda Dewey.
Wooded hillsides and thickets.
Carex brachyglossa Mackenzie.
Moist sandy soil.
Carex brevior molesta (Mack.) F. C. Gates. (F. H. Snow)
Carex bushii Mackenzie. (Gates, 1940)
Carex cephalophora Muhl.
Dry fields and open woodlands.
Carex conjuncta Boott. (Gates, 1940)
Carex davisii Schw. and Torr.
Woods and thickets.
Carex emoryi Dewey.
Low moist prairie.

Carex frankii Kunth.
Creek banks and swampy areas.
Carex gravida Bailey.
Prairie.
Carex gravida lunelliana (Mack.) Hermann. (F. H. Snow)
Carex hyalinolepis Steud. (F. H. Snow)
Carex hystricina Muhl. (Gates, 1940)
Carex jamesii Schw. (Gates, 1940)
Carex lacustris Willd.
Low moist prairies.
Carex laeviconica Dewey.
Swampy areas.
Carex lanuginosa Michx. (F. H. Snow)
Carex leavenworthii Dewey.
Low moist prairie and ditches.
Carex lupulina Muhl.
Swampy areas.
Carex meadii Dewey.
Prairie
Carex molesta Mack.
Wooded areas.
Carex retroflexa Muhl.
Wooded hillsides.
Carex rosea Schk.
Woods and thickets.
Carex rostrata Stokes.
Swampy areas.
Carex scoparia Schk. (Gates, 1940)
Carex shortiana Dewey.
Moist woodlands.
Carex siccata Dewey.
Low prairie.
Carex stipata Muhl.
Low moist prairie.
Carex tenera Dewey.
Woodlands.
Carex vulpinoidea Michx.
Swampy areas.
Cyperus acuminatus Torr. and Hook.
Moist places.
Cyperus diandrus Torr. (F. H. Snow)
Cyperus erythrorhizos Muhl.
Swampy areas.
Cyperus esculentus L. (F. H. Snow)
Cyperus filiculmis Vahl.
Dry fields and open woodlands.
Cyperus houghtoni Torr.
Wet sandy places.
Cyperus inflexus Muhl.
Creek banks, moist fields and prairie.
Cyperus ovularis (Michx.) Torr.
Open wooded hillsides.
Cyperus pseudovegetus Steud.
Swampy areas.
Cyperus schweinitzii Torr.
Moist sandy ground.
Cyperus speciosus Vahl.
Swampy areas.
Cyperus strigosus L.
Wet places in prairies, fields and along creek banks.
Eleocharis acuminata (Muhl.) Nees.
Wet places in fields and around ponds and ditches.
Eleocharis calva Torr.
Moist sandy soil.
Eleocharis elliptica Kunth. (Gates, 1940)
Eleocharis mamillata Lindb.
Roadside ditches and sandy banks.
Eleocharis obtusa (Willd.) Schultes.
Creek banks and moist places in fields.
Eleocharis tenuis (Willd.) Schultes.
Swampy areas.
Hemicarpha drummondii Nees. (W. H. Horr, 1935)
Scirpus americanus Pers. (Gates, 1940)
Scirpus atrovirens Muhl.
Swampy places.
Scirpus fluviatilis (Torr.) Gray. (Gates, 1940)
Scirpus lineatus Michx.
Swampy areas.
Scirpus validus Vahl.
Swampy areas.
Scleria triglomerata Michx. (Gates, 1940)
Stenophyllus capillaris (L.) Britton.
Sandy places and along creek banks.

Ebenaceae

Diospyros virginiana L.
Woods.

Equisetaceae

Equisetum arvense L.
Wet sandy banks and along railroad tracks.
Equisetum kansanum J. H. Schaffner.
On clay banks.
Equisetum robustum A. Br.
Common in wet places in stream valleys.

Euphorbiaceae

Acalypha gracilens A. Gray. (O. Wilson, Oct. 7, 1911)
Acalypha ostryaefolia Riddell.
Woods, thickets, waste places.
Acalypha rhomboidea Raf. (Gates, 1940)
Acalypha virginica L. (F. H. Snow)
Chamaesyce humistrata (Engelm.) Small. (F. H. Snow)
Chamaesyce hyssopifolia (L.) Small.
Fields, roadsides, thickets.
Chamaesyce maculata (L.) Small.
Railroad ballast.

Chamaesyce serpens (H.B.K.) Small.
Prairie.
Chamaesyce stictospora (Engelm.) Small.
Railroad ballast.
Croton capitatus Michx.
Roadsides, abandoned fields, pastures.
Croton glandulosus L.
Pastures, fields, waste places.
Croton monanthogynus Michx.
Dry sandy soil, fields, waste places.
Euphorbia nuttallii (Engelm.) Small. (Gates, 1940)
Galarrhoeus obtusatus (Pursh) Small.
Low prairie.
Lepadena marginata (Pursh) Nieuwl.
Rocky hillsides, thickets, creek valleys.
Poinsettia dentata (Michx.) Small.
Fields, waste places.
Poinsettia heterophylla (L.) Small.
Roadside, dry sandy soil.
Tithymalopsis corollata (L.) Small.
Prairie, waste land.
Tragia nepetaefolia Cav.
Dry sandy banks.
Tragia ramosa Torr.
Clay banks.
Zygophyllidium hexagonum (Nutt.) Small.
Sandy soil in Kaw River valley.

Fabaceae

Acmispon americanus (Nutt.) Rydb.
Dry sandy hillsides.
Amorpha canescens Pursh.
Prairie.
Amorpha fragrans Sweet.
Roadside banks, stream sides, prairie.
Amphicarpa pitcheri T. and G.
Rocky hillsides, thickets.
Apios tuberosa Moench.
Thickets.
Astragalus canadensis L. (F. H. Snow)
Astragalus plattensis Nutt. (Gates, 1940)
Baptisia leucantha T. and G.
Prairie.
Baptisia leucophaea Nutt.
Prairie.
Cracca virginiana L. (F. H. Snow)
Crotalaria sagittalis L.
Fields and waste places.
Desmodium acuminatum (Michx.) DC. (Gates, 1940)
Geoprumnon crassicarpum (Nutt.) Rydb.
Prairie.
Glycyrrhiza lepidota Nutt.
Prairie.
Lespedeza capitata Michx.
Dry, rocky hillsides.
Lespedeza repens (L.) Bart. (F. H. Snow)
Lespedeza violacea (L.) Pers.
Roadside banks.
Lespedeza virginica (L.) Britton.
Thickets, roadside banks.
Medicago lupulina L.
Fields, yards, waste places.
Medicago sativa L.
Fields, roadsides and waste places.
Meibomia bracteosa (Michx.) Kuntze.
Open woodlands, thickets.
Meibomia canescens (L.) Kuntze.
Woods and thickets.
Meibomia illinoensis (A. Gray) Kuntze.
Prairie.
Meibomia paniculata (L.) Kuntze. (F. H. Snow)
Meibomia sessilifolia (Torr.) Kuntze.
Rocky hillsides and prairie.
Melilotus alba Desv.
Waste places and roadsides.
Melilotus officinalis (L.) Lam.
Waste places and roadsides.
Parosela alopecuroides (Willd.) Rydb. (F. H. Snow)
Pediomelum esculentum (Pursh) Rydb.
Prairie.
Petalostemon candidus (Willd.) Michx.
Rocky hillsides, prairie.
Petalostemon multiflorus Nutt.
Roadside banks, prairie.
Petalostemon purpureus (Vent.) Rydb.
Open wooded hillsides, prairie.
Psoralea floribunda Nutt. (Gates, 1940)
Psoralidium argophyllum (Pursh) Rydb.
Prairie.
Psoralidium digitatum (Nutt.) Rydb.
Sandy banks, prairie.
Robinia pseudo-acacia L.
Woods, thickets, overgrazed pastures.
Strophostyles helvola (L.) Ell.
Sandy hillsides and thickets.
Strophostyles leiosperma (T. and G.) Piper.
Woods, streambanks, thickets.
Trifolium pratense L.
Roadsides, pastures, fields.
Trifolium repens L.
Roadsides, pastures, waste places.
Vicia americana Muhl.
Prairie, thickets.

Vicia sparsifolia Nutt.
Roadside ditches, thickets.
Vicia villosa Roth.
Fields, waste places.

Fagaceae

Quercus alba L.
Wooded hillsides.
Quercus imbricaria Michx.
Woods.
Quercus macrocarpa Michx.
Rich woods and along streams.
Quercus marilandica Munchh.
Dry sandy soil.
Quercus maxima (Marsh.) Ashe.
Rocky wooded hillsides.
Quercus muhlenbergii Engelm.
Rocky wooded hillsides.
Quercus palustris Munchh.
Moist woods.
Quercus prinoides Willd.
Rocky hillsides and sandy banks.
Quercus stellata Wang.
Dry rocky or sandy woodlands.
Quercus velutina Lam.
Dry upland woods.

Fumariaceae

Corydalis campestris (Britton) Buckholz and Palmer. (Gates, 1940)
Corydalis flavula (Raf.) DC.
Wooded hillsides, thickets and prairies.
Corydalis micrantha (Engelm.) Gray. (Gates, 1940)
Corydalis montana Engelm.
Streambanks, wooded hillsides and thickets.
Dicentra cucullaria (L.) Bernh.
Woods.

Gentianaceae

Centaurium texense (Griseb.) Fern.
Dry rocky hillsides.
Dasystephana puberula (Michx.) Small.
Prairie.

Geraniaceae

Geranium carolinianum L.
Fields, roadsides, creekbanks, waste places.

Grossulariaceae

Chrysobotrya odorata (Wendl.) Rydb.
Roadside bank.
Grossularia missouriensis (Nutt.) Cov. and Britt.
Woods and thickets.

Hippocastanaceae

Aesculus arguta Buckl.
Woods, creek valleys.

Hydrophyllaceae

Ellisia nyctelea L.
Fields, roadsides, woods, waste places.
Hydrophyllum virginianum L.
Moist woods.

Hypericaceae

Hypericum cistifolium Lam.
Creek banks.
Hypericum mutilum L.
Swampy places.
Hypericum perforatum L.
Roadsides, low prairie.
Hypericum punctatum Lam.
Open wooded hillsides.

Iridaceae

Sisyrinchium campestre Bickn.
Prairies and rocky open woodlands.
Sisyrinchium graminoides Bickn.
Moist prairies and in woodlands.

Juglandaceae

Carya cordiformis (Wang.) K. Koch.
Rich woods and along streams.
Carya glabra (Mill.) Spach.
Wooded hillsides.
Carya ovata (Mill.) K. Koch.
Rich woods.
Carya laciniosa (Michx. f.) Loud.
Wooded hillsides and along streams.
Carya pecan (Marsh.) C. K. Schneid.
Moist woodlands.
Carya tomentosa Nutt. (Gates, 1940)
Juglans nigra L.
Rich woods and along streams.

Juncaceae

Juncus ater Rydb.
Low prairie.
Juncus dudleyi Wieg.
Low wet prairies.
Juncus interior Wieg.
Prairies and open woodlands.
Juncus marginatus Rostk.
Moist sandy places.
Juncus tenuis Willd.
Roadside ditches and low prairies.
Juncus torreyi Coville.
Wet sandy places.

Juniperaceae

Sabina virginiana (L.) Antoine.
Scattered in wooded hillsides.

Lamiaceae

Agastache nepetoides (L.) Kuntze.
Woods and thickets.
Dracocephalum formosius (Lunell) Rydb.
Swampy places.
Hedoma hispida Pursh.
Rocky hillsides and sandy places.

Hedeoma pulegioides (L.) Pers.
Open wooded hillsides and thickets.
Isanthus brachiatus (L.) B.S.P.
Rocky hillsides, prairie.
Lamium amplexicaule L.
Lawns, fields, waste places.
Lamium purpureum L.
Open woods.
Leonurus cardiaca L.
Roadsides, waste places.
Lycopus americanus Muhl.
Streambanks, moist woods, swampy places.
Lycopus virginicus L.
Moist woods.
Marrubium vulgare L.
Pastures, waste places.
Mentha glabrior (Hook.) Rydb.
Swampy places along streams.
Monarda mollis L.
Rocky hillsides, thickets.
Nepeta cataria L.
Roadsides, pastures, thickets, waste places.
Nepeta hederacea parviflora Benth. (Gates, 1940)
Prunella vulgaris L.
Moist woods and thickets.
Pycnanthemum flexuosum (Walt.) B.S.P.
Rocky hillsides, thickets, prairie.
Pycnanthemum pilosum Nutt. (Gates, 1940)
Salvia lanceolata Willd.
Fields, prairie, waste ground.
Salvia pitcheri Torr.
Dry hillsides and prairie.
Scutellaria ambigua Nutt.
Prairie.
Scutellaria lateriflora L.
Swampy places along streams.
Stachys pustulosa Rydb.
Swampy places.
Stachys tenuifolia Willd.
Moist woods and thickets.
Teucrium canadense L.
Roadsides, thickets, streambanks, waste places.

Lemnaceae

Lemna minor L.
Swamps and lakes.
Lemna perpusilla Torr.
Ponds and lakes.
Spirodela polyrhiza (L.) Schleiden.
Found only in Lakeview lake.

Liliaceae

Camassia esculenta (Kerr) B. L. Robinson.
Low prairies and open wooded hillsides.
Erythronium albidum Nutt.
Woods and thickets.
Erythronium mesochoreum Knerr.
Prairies and open woodlands.
Hemerocallis fulva L.
Roadside ditches and banks.
Lilium canadense L.
Low moist prairie.
Ornithogalum umbellatum L.
Roadside.

Linaceae

Cathartolinum sulcatum (Riddell) Small.
Dry sandy soil, prairie.
Linum lewisii Pursh.
Waste places and fields.
Linum usitatissimum L. (Gates, 1940)

Loasaceae

Mentzelia oligosperma Nutt.
Rocky hillsides, thickets, prairie.

Lobeliaceae

Lobelia cardinalis L.
Low wet ground.
Lobelia leptostachys A. DC.
Prairie, open wooded hillsides.
Lobelia syphilitica L.
Streambanks and swampy places.

Lythraceae

Ammannia coccinea Rottb.
Creek banks, swampy areas.
Cuphea petiolata (L.) Koehne.
Open wooded hillsides.
Lythrum alatum Pursh.
Woods, roadside ditches, swampy places.

Malaceae

Crataegus crus-galli L.
Rocky hillsides.
Crataegus mollis (T. and G.) Scheele.
Rocky hillsides, open woods, along streams.
Malus ioensis (Wood) Britt.
Rocky hillsides.

Malvaceae

Abutilon theophrasti Medic.
Fields and waste places.
Althaea rosea Cav.
Roadsides and waste places.
Callirrhoe alceoides (Michx.) A. Gray.
Railroad ballast.
Callirrhoe involucrata (T. and G.) A. Gray.
Prairie.
Hibiscus militaris Cav.
Swampy places.
Hibiscus trionum L.
Fields and waste places.

Malva rotundifolia L.
Fields and waste places.
Sida spinosa L.
Fields and waste places.

Martyniaceae

Proboscidea louisiana (Mill.) Woot. and Standl.
Pastures, fields, waste places.

Melanthiaceae

Melanthium virginicum L.
Low prairies.

Menispermaceae

Cocculus carolinum (L.) DC.
Woods and thickets.
Menispermum canadense L.
Wooded hillsides and thickets.

Mimosaceae

Desmanthus illinoensis (Michx.) MacMill.
Rocky hillsides, thickets, prairie.
Leptoglottis nuttallii DC.
Rocky banks, prairie.

Moraceae

Maclura pomifera (Raf.) C. K. Schneid.
Roadsides and waste places.
Morus alba L.
Roadsides, fields and waste places.
Morus nigra L.
Roadsides and waste places.
Morus rubra L.
Around dwellings and waste places.

Nelumbonaceae

Nelumbo lutea (Willd.) Pers.
Swampy areas and shallow ponds.

Nyctaginaceae

Allionia linearis Pursh.
Dry fields and waste places.
Allionia nyctaginea Michx.
Roadsides, fields, waste places.

Nymphaeaceae

Nymphaea odorata Ait.
Found only in the lake at Lakeview.

Oleaceae

Fraxinus americana L.
Woods.
Fraxinus lanceolata Borkh.
Streambanks, woods.

Onagraceae

Circaea latifolia Hill. (Gates, 1940)
Gaura biennis L.
Roadsides, rocky hillsides, waste places.
Gaura parviflora Dougl.
Railroad ballast, prairie.
Gaura sinuata Nutt.
Dry rocky hillsides.
Hartmannia speciosa (Nutt.) Small.
Roadsides, prairie.
Isnardia palustris L.
Shallow water and swampy places.
Jussiaea diffusa Forsk.
Ponds and swamps.
Lavauxia triloba (Nutt.) Spach.
Dry prairie.
Ludwigia alternifolia L.
Low moist places.
Megapterium missouriense (Sims) Spach.
Rocky hillsides, prairie.
Oenothera biennis L.
Dry soil, roadsides, railroad ballast.
Oenothera laciniata Hill.
Dry sandy soil.
Oenothera strigosa (Rydb.) Mack. and Bush.
Dry sandy soil.
Stenosiphon linifolius (Nutt.) Britton.
Dry hillsides, prairie.

Ophioglossaceae

Botrychium obliquum Muhl.
One specimen found in a moist woods three miles northeast of Baldwin City.
Botrychium virginianum (L.) Sw.
Found in moist woods and thickets.
Ophioglossum engelmanni Prantl.
Found once in a damp meadow and once on a wooded, rocky, roadside bank.
Ophioglossum vulgatum L. (K. U. Herb.)

Orchidaceae

Blephariglottis leucophaea (Nutt.) Farwell.
Low moist prairie.
Cypripedium parviflorum Salsib.
Rich woodlands.
Galeorchis spectabilis (L.) Rydb.
Woods.
Spiranthes cernua (L.) Richard.
Prairies.
Spiranthes vernalis Engelm. and Gray.
Prairies and sandy woodlands.

Orobanchaceae

Orobanche uniflora L. (Gates, 1940)

Oxalidaceae

Ionoxalis violacea (L.) Small.
Roadsides, fields.
Oxalis europaea bushii (Small) Wiegand. (Gates, 1940)
Xanthoxalis corniculata (L.) Small.
Hillsides, creek banks, waste places.
Xanthoxalis stricta (L.) Small.
Woods, roadsides, fields.

Papaveraceae

Argemone intermedia Sweet.
One specimen found along railroad track north of Lawrence.
Sanguinaria canadensis L.
Woods.

Penthoraceae

Penthorum sedoides L.
Streambanks and wet places.

Phrymaceae

Phryma leptostachya L.
Woods and thickets.

Phytolaccaceae

Phytolacca decandra L.
Along streams, open woodlands and waste places.

Plantaginaceae

Plantago aristata Michx.
Dry sandy soil.
Plantago lanceolata L.
Lawns, fields, waste places.
Plantago major L.
Lawns, roadsides, fields, waste places.
Plantago purshii R. and S.
Sandy soil.
Plantago pusilla Nutt.
Moist sandy banks.
Plantago rhodosperma Decne.
Dry fields, pastures, waste places.
Plantago rugelii Decne.
Woods, pastures, waste places.
Plantago virginica L.
Pastures, prairie, waste places.

Platanaceae

Plantanus occidentalis L.
Woods and along streams.

Poaceae

Aegilops cylindrica Host.
In fields, fence rows, roadsides and waste places.
Agropyron smithii Rydb.
In prairies.
Agrostis elliottiana Schultes.
Dry clay fields and waste places.
Agrostis hyemalis (Walt.) B.S.P.
Common on dry sandy soil or clay banks.
Agrostis palustris Huds.
Common in moist meadows and in woods.
Alopecurus geniculatus L.
Waste places and roadsides.
Andropogon provincialis Lam.
Common in all prairies and open rocky woods.
Andropogon scoparius Michx.
Prairies, open woods and sandy banks.
Andropogon virginicus L. (Gates, 1940)
Aristida dichotoma Michx.
Dry sandy soil.
Aristida oligantha Michx.
Common on dry sandy soils and found particularly in abandoned fields on clay soil.
Aristida purpurascens Poir.
Dry, sandy soil.
Avena sativa L.
Escaped to fence rows, abandoned fields and along railroads.
Bouteloua curtipendula (Michx.) Torr.
Prairie, rocky or sandy hillsides.
Bouteloua gracilis (H.B.K.) Lag.
Prairie and sandy hillsides.
Bouteloua hirsuta Lag.
Prairie and sandy hillsides.
Bromus commutatus Schrader.
Fields and waste places.
Bromus inermis Leyss.
Common in fields and waste places.
Bromus patulus Mert. and Koch.
Waste places.
Bromus purgans L.
Moist open woods.
Bromus purgans latiglumis (Scribn.) Shear (Gates, 1940)
Bromus racemosus L. (Gates, 1940)
Bromus secalinus L.
Fields and waste places.
Bromus tectorum L.
Dry fields or on sandy soil.
Cenchrus pauciflorus Benth.
Sandy banks and waste places.
Chloris verticillata Nutt.
Waste places.
Chloris virgata Swartz. (W. H. Horr, Aug. 3, 1938)
Cinna arundinacea L.
Moist woods.
Dactylis glomerata L.
Fields and waste places.
Diarrhena aurundinacea (Zea) Rydb.
In rich woods and moist places in prairie.
Echinochloa crus-galli (L.) Beauv.
Fields, waste places, roadsides and streambanks.
Echinochloa microstachya (Wieg.) Rydb.
Most common in creek valleys.
Eleusine indica (L.) Gaertn.
Roadsides, fields and waste places.
Elymus canadensis L.
Roadside banks and creek valleys.
Elymus canadensis brachystachys (Scribn. and Ball.) Farwell (Gates, 1940)

Elymus glabriflorus (Vasey) Schribn. and Ball.
Open woods and thickets.
Elymus robustus Scribn. and Smith.
Common on moist banks and in roadside ditches.
Elymus villosus Muhl. (Gates, 1940)
Elymus villosus arkansanus (Scribn. and Ball) Hitchc. (Gates, 1940)
Elymus virginicus L.
In prairies and occasionally in woods and thickets.
Elymus virginicus submuticus Hook. (Gates, 1940)
Eragrostis capillaris (L.) Nees.
Roadsides and waste places.
Eragrostis cilianensis (All.) Link.
Fields and waste places.
Eragrostis hypnoides (Lam.) B.S.P.
Moist sandy soil.
Eragrostis pectinacea (Michx.) Nees. (W. H. Horr, 1937)
Eragrostis pilosa (L.) Beauv.
Cultivated fields and waste places.
Eragrostis poaeoides Beauv.
Fields and waste places.
Eragrostis reptans (Michx.) Nees. (W. H. Horr, 1939)
Eragrostis spectabilis (Pursh.) Steud. (F. H. Snow)
Eragrostis trichodes (Nutt.) Nash.
Sandy banks and hillsides.
Eriochloa contracta Hitchc.
Moist meadows and waste places.
Festuca elatior L.
Low prairies, meadows and waste places.
Festuca obtusa Spreng. (Gates, 1940)
Festuca octoflora Walt.
Sandy soils in prairies.
Festuca ovina L. (W. H. Horr, May 25, 1935)
Festuca paradoxa Desv. (Gates, 1940)
Glyceria nervata (Willd.) Trin.
Low prairies.
Hordeum jubatum L.
Dry sandy soil and prairie.
Hordeum pusillum Nutt.
Dry soil and waste places.
Hordeum vulgare L.
Occasionally along roads and railroads.
Hystrix patula Moench.
In woods.
Koeleria gracilis Pers.
Common in prairies.
Leersia oryzoides (L.) Swartz. (F. H. Snow)
Leersia virginica Willd.
Low moist ground.
Leptochloa filiformis (Lam.) Beauv.
Sandy soil and waste places.
Leptoloma cognatum (Schultes) Chase.
Dry sandy soil.
Lolium perenne L.
Fields and waste places.
Melica nitens Nutt.
Most common in rocky woods and thickets.
Muhlenbergia capillaris (Lam.) Trin.
Dry sandy soil.
Muhlenbergia mexicana (L.) Trin. (F. H. Snow)
Muhlenbergia racemosa (Michx.) B.S.F.
Low prairies and in thickets.
Muhlenbergia schreberi Gmel.
Dry hill sides and open woods.
Panicum capillare L.
Dry or sandy soil and waste places.
Panicum clandestinum L.
Low prairies.
Panicum dichotomiflorum Michx.
Wet places and in woods.
Panicum helleri Nash. (W. C. Booth, July 18, 1936)
Panicum huachucae fasciculatum (Torr.) F. T. Hubb.
In open woods.
Panicum leibergii (Vasey) Scribn. (F. H. Snow)
Panicum miliaceum L. (Gates, 1940)
Panicum scoparium Lam. (W. E. Booth, July 14, 1936)
Panicum scribnerianum L. (F. H. Snow)
Panicum tennesseense Ashe.
Edge of woods and in thickets.
Panicum virgatum L.
On sandy soil in prairies.
Paspalum muhlenbergii Nash.
Sandy soil in woods.
Phalaris arundinacea L.
Low wet places.
Phalaris canariensis L.
Common in waste places.
Phleum pratense L.
Along railroad right of ways and roadsides.
Phragmites communis berlandieri (Fourier) Fernald.
Poa annua L.
Waste places.
Poa chapmaniana Scribner (W. H. Horr, 1942)
Poa compressa L.
Dry soil in meadows and woodlands.
Poa pratensis L.
Fields and woodlands.
Schedonnardus paniculatus (Nutt.) Trelease.
Sandy soil in prairies.

Setaria italica (L.) Beauv.
Roadsides and railroads.
Setaria lutescens (Weigel) Stuntz.
Fields and waste places.
Setaria viridis (L.) Beauv.
Fields and waste places.
Sorghastrum nutans (L.) Nash.
Low prairies.
Sorghum halepense (L.) Pers.
Fields and waste places.
Spartina pectinata Bosc.
Low prairies and swampy areas.
Sphenopholis obtusata (Michx.) Scribn.
Common in prairies.
Sporobolus asper (Michx.) Kunth.
Dry sandy soil in prairies.
Sporobolus cryptandrus (Torr.) A. Gray.
Sandy soil in prairies and open rocky woodlands.
Sporobolus heterolepis A. Gray.
Common in prairies.
Sporobolus neglectus Nash. (Gates, 1940)
Sporobolus vaginiflorus (Torr.) Wood.
Dry fields and waste places.
Stipa spartea Trin.
Common in prairies.
Syntherisma sanguinale (L.) Dulac.
Fields, roadsides and waste places.
Tridens flavus (L.) Hitchc.
Prairies and open woods.
Tripsacum dactyloides L.
Low moist prairies.
Triticum aestivum L.
Roadsides and waste places.
Uniola latifolia Michx.
Rich woods and thickets.

Podophyllaceae

Podophyllum peltatum L.
Woods.

Polemoniaceae

Phlox divaricata L.
Woods and thickets.
Phlox pilosa L.
Prairie and rocky hillsides.

Polygalaceae

Polygala incarnata L.
Sandy soil.
Polygala verticillata L.
Open woods, thickets.
Polygala viridescens L.
Moist sandy banks.

Polygonaceae

Bilderdykia convolvulus (L.) Dum.
Waste places, fields.
Bilderdykia scandens (L.) Greene.
Thickets and waste places.
Fagopyrum esculentum Moench.
Waste places.
Persicaria hydropiper (L.) Opiz.
Wet places.
Persicaria lapathifolia (L.) S. F. Gray.
Low moist places.
Persicaria maculosa S. F. Gray.
Waste places.
Persicaria pennsylvanica (L.) Small.
Low fields and waste places.
Persicaria pratincola Greene.
Swampy areas.
Persicaria punctata (Ell.) Small.
Low wet places.
Polygonum achoreum Blake.
Waste places and sandy hillsides.
Polygonum buxiforme Small.
Sandy soil, waste places.
Polygonum erectum L.
Waste places.
Polygonum longistylum Small. (Gates, 1940)
Polygonum neglectum Besser.
Fields and waste places.
Polygonum orientale L. (Gates, 1940)
Polygonum prolificum (Small) B. L. Robinson.
Sandy banks and waste places.
Polygonum tenue Michx.
Rocky hillsides and dry sandy soil.
Rumex acetosa L.
Waste places.
Rumex acetosella L.
Fields and waste places.
Rumex altissimus Wood.
Streambanks, fields and waste places.
Rumex crispus L.
Fields and waste places.
Rumex patientia L. (Gates, 1940)
Tovara virginiana (L.) Adans.
Woods, streambanks and thickets.
Tracaulon sagittatum (L.) Small.
Low wet places.

Polypodiaceae

Adiantum pedatum L.
In damp woods or on shaded, rocky, moist banks.
Asplenium platyneuron (L.) Oakes.
A few specimens located on a sandy bank in a roadside thicket one-half mile east of Baldwin City Lake.
Camptosorus rhizophyllus (L.) Link.
On shaded calcareous rocks.
Dryopteris thelypteris (L.) A. Gray.
One location and that in the south-west corner of Lone Star Lake.
Filix fragilis (L.) Gilib.
Commonly found on moist wooded hillsides.

Notholaena dealbata (Pursh.) Kunze.
One location and that on limestone rocks three miles west of Lone Star Lake.
Onoclea sensibilis L.
A few specimens were found in a swampy region at north end of Baldwin Lake.
Pellaea atropurpurea Link.
On calcareous rocks in Lecompton and Lone Star areas.
Pellaea glabella Nutt.
Found on a dry sandstone cliff six miles south of Eudora.
Woodsia obtusa Torr.
Found frequently on damp, shaded sandy banks or on rocky, wooded hillsides.

Pontederiaceae

Heteranthera limosa (Sw.) Willd.
Shallow water and muddy banks.
Heteranthera peduncularia Benth.
Shallow water and muddy banks.

Portulacaceae

Claytonia virginica L.
Rocky wooded hillsides.
Portulaca oleracea L.
Dry sandy soil.
Portulaca parvula A. Gray.
Dry sandy soil.
Talinum parviflorum Nutt.
Dry sandy soil.

Primulaceae

Androsace occidentalis Pursh.
Sandy soil, open woods, rocky prairie.
Steironema ciliatum (L.) Raf.
Streambanks, moist woods and thickets.
Steironema hybridum (Michx.) Raf.
Woods and thickets.

Ranunculaceae

Anemone canadensis L. (W. H. Horr, 1934)
Anemone caroliniana Walt.
Dry prairie.
Anemone virginiana L.
Low prairie woods and thickets.
Aquilegia latiuscula Greene.
Open wooded hillsides.
Delphinium ajacis L.
Roadsides and waste places.
Delphinium tricorne Michx.
Low prairie and in woods.
Delphinium virescens Nutt.
Prairie and rocky wooded hillsides.
Isopyrum biternatum (Raf.) T. and G.
Moist woods and thickets.
Myosurus minimus L.
Streambanks and in moist woods.
Ranunculus abortivus L.
Woods, thickets and waste places.
Ranunculus fascicularis apricus (Greene) Fernald. (Gates, 1940)
Ranunculus flabellaris Raf. (Gates, 1940)
Ranunculus recurvatus Poir.
Rocky wooded hillsides.
Ranunculus sceleratus L.
Sandy soil of Kaw River valley.
Syndesmon thalictroides (L.) Hoffmgg.
Woods.
Thalictrum dasycarpum Fisch. and Ave-Lall.
Prairie.
Thalictrum dasycarpum f. hypoglaucum (Rydb.) Steyermark. (Gates, 1940)
Viorna pitcheri (T. and G.) Britton.
Woods and thickets.

Rhamnaceae

Ceanothus americanus L.
Woods and hillsides.
Ceanothus ovatus Desf.
Dry soil, prairie.
Ceanothus ovatus pubescens T. and G. (Gates, 1940)
Rhamnus lanceolata Pursh.
Thickets, creek valleys.

Rosaceae

Agrimonia parviflora Ait.
Moist wooded hillsides and thickets.
Agrimonia pubescens Wallr.
Wooded hillsides.
Fragaria americana (Porter) Britton.
Rocky wooded hillsides.
Fragaria grayana E. Vilm.
Open wooded hillsides.
Fragaria virginiana Duchesne.
Prairie.
Geum canadense camporum (Rydb.) Fernald and Weatherby. (Gates, 1940)
Geum canadense Jacq.
Roadside banks, thickets, prairie.
Geum vernum (Raf.) T. and G.
Woods.
Potentilla canadensis L.
Prairie.
Potentilla monspeliensis L.
Swampy areas.
Potentilla paradoxa Nutt.
Low moist ground.
Potentilla pentandra Engelm.
Alluvial soil of Kansas River valley.
Rosa blanda Ait.
Prairie, thickets.

Rosa rubifolia R. Br.
Thickets, prairie.
Rosa rudiuscula Greene.
Roadsides, thickets.
Rosa suffulta Greene.
Prairie, roadsides.
Rubus argutus Link.
Thickets, roadsides.
Rubus flagellaris Willd.
Rocky hillsides, thickets.
Rubus frondosus Bigel.
Thickets.
Rubus nigrobaccus Bailey.
Open woods.
Rubus occidentalis L.
Hillsides and thickets.

Rubiaceae

Cephalanthus occidentalis L.
Swampy places, edge of lakes, streambanks.
Diodia teres Walt.
Creek banks, swampy places, low prairie.
Galium aparine L.
Woods, thickets, fields, waste places.
Galium circaezans Michx.
Woods and thickets.
Galium concinnum T. and G. (F. H. Snow)
Galium tinctorium L.
Moist woods, low prairie.
Galium triflorum Michx.
Moist woods.
Galium vaillantii DC.
Woods and thickets.
Houstonia angustifolia Michx.
Dry rocky hillsides.
Houstonia minima Beck.
Open woods, pastures, lawns, waste places.

Rutaceae

Zanthoxylum americanum Mill.
Woods and thickets.

Salicaceae

Populus virginiana Fourg.
Along streambanks and in moist places.
Salix amygdaloides Anders.
Streambanks and moist woodlands.
Salix cordata Muhl. (F. H. Snow)
Salix fragilis L. (Gates, 1940)
Salix humilis Marsh.
Dry prairie.
Salix humilis rigidiuscula Anders. (Gates, 1940)
Salix interior Rowlee.
Sandbars and streambanks.
Salix missouriensis Bebb.
Streambanks and moist woodlands.
Salix nigra Marsh.
Streambanks and wet places.
Salix tristis Ait.
In sandy prairie.

Santalaceae

Comandra pallida A. DC. (Gates, 1940)
Comandra richardsoniana Fern.
Prairie and dry sandy soil.

Saxifragaceae

Heuchera hispida Pursh.
Moist wooded hillsides.

Scrophulariaceae

Dasystoma macrophylla (Nutt.) Raf.
Woods and thickets.
Ilysanthes dubia (L.) Barnhart.
Streambanks, sandbars.
Ilysanthes inequalis (Walt.) Pennell.
Wet places.
Leucospora multifida (Michx.) Nutt.
Streambanks, prairie.
Linaria canadensis (L.) Dumort.
Sandy places.
Linaria texana Scheele.
Sandy soil, prairie.
Macuillamia rotundifolia Michx.
Shallow water, swampy places.
Mimulus alatus Solander.
Streambanks, woods, moist meadows.
Mimulus ringens L.
Moist woods, swampy places.
Pedicularis canadensis L.
Prairie, open woods, thickets.
Pentstemon albidus Nutt.
Prairie.
Pentstemon cobaea Nutt.
Rocky hillsides, prairie.
Pentstemon digitalis (Sweet) Nutt.
Prairie.
Pentstemon tubiflorus Nutt.
Low prairie.
Scrophularia marilandica L.
Woods and thickets.
Tomanthera auriculata (Michx.) Raf. (F. H. Snow)
Verbascum blattaria L.
Fields, pastures, waste places.
Verbascum thapsus L.
Rocky hillsides, pastures, waste places.
Veronica arvensis L.
Fields, pastures, waste places.
Veronica peregrina L.
Streambanks, low prairie.
Veronica xalapensis H.B.K.
Moist sandy places.
Veronicastrum virginicum (L.) Farwell.
Prairie, thickets.

Simarubaceae

Ailanthus glandulosa Desf.
Fence rows and around abandoned dwellings.

Smilacaceae

Nemexia ecirrhata (Engelm.) Small.
Woods.
Nemexia lasioneuron (Hook.) Rydb.
Woods and thickets.
Smilax hispida Muhl.
Woods and thickets.

Solanaceae

Androcera rostrata (Dunal) Rydb.
Fields, waste places, prairie.
Datura metel L.
Waste places.
Datura stramonium L.
Cultivated fields and waste places.
Datura tatula L.
Fields and waste places.
Lycium halimifolium Mill.
Roadside banks.
Physalis comata Rydb.
Rocky hillsides.
Physalis heterophylla Nees.
Fields, waste places.
Physalis lanceolata Michx.
Roadsides, prairie.
Physalis longifolia Nutt. (Gates, 1940)
Physalis macrophysa Rydb.
Woods and thickets.
Physalis missouriensis Mack. and Bush. (Gates, 1940)
Physalis pumila Nutt.
Fields, waste places, prairie.
Physalis subglabrata Mack. and Bush.
Sandy creek bank.
Physalis virginiana Mill. (F. H. Snow)
Solanum carolinense L.
Fields, roadside, prairie, waste places.
Solanum elaeagnifolium Cav.
Railroad ballast.
Solanum nigrum L.
Woods, thickets, waste places.
Solanum nigrum interius (Rydb.) F. C. Gates. (Gates, 1940)

Sparganiaceae

Sparganium americanum Nutt.
Only known location is at the north end of Baldwin Lake.
Sparganium eurycarpum Engelm.
In swampy areas, along streams and in shallow ponds.

Staphyleaceae

Staphylea trifoliata L.
Thickets, woods.

Tamaricaceae

Tamarix gallica L.
Kansas River sandbar. Rare.

Tetragoniaceae

Mollugo verticillata L.
Fields and waste places.

Tiliaceae

Tilia americana L.
Woods.

Typhaceae

Typha angustifolia L.
Found only in swampy areas in the Kansas River valley.
Typha latifolia L.
Common in nearly all swampy or seepage areas and in shallow water lakes and ponds.

Ulmaceae

Celtis occidentalis L.
Rocky wooded hillsides.
Celtis crassifolia Lam.
Woods.
Ulmus americana L.
Woods.
Ulmus fulva Michx.
Rich woods along streams.
Ulmus pumila L.
Roadsides.

Urticaceae

Boehmeria cylindrica (L.) Sw.
Moist woods and thickets.
Laportea canadensis (L.) Gaud.
Shaded banks, woods and thickets.
Parietaria pennsylvanica Muhl.
Shaded banks, woods and thickets.
Pilea pumila (L.) A. Gray.
Damp shaded places.
Urtica procera Muhl.
Along streams and in waste places.
Urtica urens L.
Woods and waste places.

Valerianaceae

Valerianella stenocarpa (Engelm.) Krok.
Low prairie.

Verbenaceae

Phyla lanceolata (Michx.) Greene.
Creek banks, wet places.
Verbena angustifolia Michx.
Pastures, rocky hillsides.
Verbena bipinnatifida Nutt. (Gates, 1940)
Verbena bracteosa Michx.
Lawns, fields, roadsides, waste places.
Verbena canadensis (L.) Britton.
Roadsides, rocky banks, prairie.
Verbena hastata L.
Pastures and waste places.

Verbena stricta Vent.
Pastures and waste places.
Verbena urticifolia L.
Woods, low prairie, roadsides.

Violaceae

Viola cucullata Ait.
Low moist prairie.
Viola eriocarpa Schw.
Open wooded hillsides, creek banks.
Viola missouriensis Greene.
Creek banks, woods.
Viola papilionacea Pursh.
Woods, creek banks, prairie.
Viola pedata L.
Dry rocky hillsides, edge of dry woods.
Viola pedatifida G. Don.
Prairie, rocky open wooded hillsides.
Viola pubescens Ait.
Woods.
Viola rafinesquii Greene.
Fields, lawns, prairie.
Viola sororia Willd.
Creek banks, woods, thickets.

Vitaceae

Ampelopsis cordata Michx. (Gates, 1940)
Muscadinia rotundifolia (Michx.) Small.
Thickets, sandy banks.
Psedera quinquefolia (L.) Greene.
Woods and thickets.
Vitis cinera Engelm. (Gates, 1940)
Vitis cordifolia Michx.
Woods and thickets.
Vitis vulpina L.
Woods, thickets, streambanks.

Zanichelliaceae

Potamogeton americanus Cham. and Schlecht.
Common in swamps, ponds, lakes and slow moving streams.
Potamogeton foliosus Raf.
Common in swamps, lakes and slow moving streams.

Zygophyllaceae

Tribulus terrestris L.
Sandy places, fields, railroad ballast.

Summary

In this work the flora of Douglas County, Kansas, was studied in all the different environments to be found in the county. The flora of the present time is vastly different from that present before the white man brought his disturbing influence to the region.

Previous to this work, the known number of species based on Herbarium specimens for the county was 650. As a result of this work, the number of known species is raised to 932. It is estimated that the total number of species to be found will total approximately 1100 if a complete survey was to be made.

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Unisexual Mating in a Flock of White Leghorn Hens[1,2]

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Observations of hens mating with hens, although rare, have been noted. Heuser (1916) reported a case of a White Leghorn hen which attempted to mate 35 times with 13 different individuals, "in as perfect a manner as the best male and better than a good many others." These occurred at time of production and non-production and while the males were present or absent. Guhl, Collias, and Allee (1945) reported 20 unisexual matings in which three apparently normal hens assumed the male role with six different hens. The vents met during 10 of these observations. All three of these hens were laying or laid within four days of these pseudo-matings, and each was socially dominant over the female trod. Heuser's observations were made prior to the now common knowledge of social dominance (c.f., Allee, 1942a, or 1942b, for a review of social organization among vertebrates).

The hens described in the 1945 report were obtained from Indiana Farm Bureau stock. Recently the present author noted unisexual behavior by two pullets which were obtained as chicks from a hatchery in Missouri. The more extensive observations reported here were made on stock of the Department of Poultry Husbandry, Kansas State College. All these flocks were White Leghorns. The indications are that such aberrant behavior is not limited to a particular strain of White Leghorns.

Observations

The data presented in this report were obtained during the course of observations on mating behavior in a flock of 42 females. Three males were caged within the larger pen of this flock and permitted to run singly with the hens for a total of 63 minutes per day. Under these conditions the females may have been more receptive than if the males had been continuously among the hens. This flock was under observation from November 14, 1946, to July 13, 1947, and the hens were in their first year of production.

Five hens of this flock were seen to assume the male role with

[1]The experiment from which the following observations were obtained was supported in part by the Committee on Problems in Sex of the National Research Council. The birds as well as their housing, care and feed were furnished by the Department of Poultry Husbandry, Kansas State College.

[2]Contribution No. 213 from Department of Zoology, and the Kansas Agricultural Experiment Station.

27 individual hens. The first incidence of unisexual mating occurred during the third week after the flock was assembled, and presumably social adjustments were well under way although reversals in the peck-order, or social organization, did occur subsequently. These hens were not necessarily very aggressive individuals. Their social ranks were 4, 15, 24, 28, and 35 in the hierarchy of 42 hens based on the number of individuals each pecked. Nor did they appear to display other masculine tendencies such as crowing or waltzing (c.f., Guhl, Collias, and Allee, 1945).

Comb size is an indicator of androgen concentration in the blood (Domm, 1927: Koch, 1937) and the examination of the comb of these hens may therefore be of interest. The mean comb size of the 42 females was 97.9 x 52.2 mm. (length x height). The largest comb among the five hens which mated was 105 x 58 mm., and 14 of this flock had combs as large or larger. The smallest comb among the treading hens was 88 x 41 mm. and only five of the 42 hens had smaller combs. These data do not indicate that a difference in androgen concentration is the primary factor related to the occurrence of male-like copulatory behavior in these hens.

Social dominance and mating: A total of 181 pseudo-matings and attempts to mate were noted during a span of 29 weeks. In all but eight, or 173 instances, the female which mounted was socially dominant over the female which was trod. Nearly all of these matings were by two individuals; 1YR trod 124 times, seven of which were on hens to which it was socially inferior, and hen 1R trod 52 times, all of which were on socially inferior hens. Hen 1R was fourth in the dominance ranking and 1YR was fifteenth. Of 1YR's matings 95 were on hens in the lowest third of the peck-order. Social dominance was not essential for pseudo-mating although it appeared to facilitate this aberrant behavior.

The conditions under which these matings were evoked were not noticed in 50 instances, as the attention was focused upon the males during an experiment on normal mating activities. Twenty-one followed the crouching of the mated hen as a response to being threatened by her superior, i.e., these were initiated by dominance-submission behavior. Three followed the crouching response to courting by a male which failed to mount and thereby permitted one of these five hens to tread. In the majority of instances the hen taking the normal female role was either resting on the floor or dusting when the male-like behavior ensued.

In one instance 1YR mounted a socially superior hen as the

latter turned her head and uttered a threat call, and 1YR dismounted without attempting to mate. On several occasions mild vocal threats from dominant hens were sufficient to cause 1YR to refrain from mounting. Some females avoided the treading hens, and occasionally the hen trod struggled and thereby prevented the completion of the mating act. In 135 of these matings the vents of the two individuals met as in normal matings.

Mating by cocks and hens: Pseudo-matings occurred in the presence or absence of males. Typically, the cocks did not interfere with unisexual matings. In three instances the male either pecked the treading female lightly or pushed her from treading position. Normal cocks may interfere with matings (Guhl and Warren, 1946). Apparently the males recognized these individuals as females; at least they reacted normally to these female penmates. On four occasions the male mated the treading hen as she dismounted, and in one instance the male mounted the treading female while it was still in the act of mating. In one sequence of events ♂ G mated ♀ 3YB, and as the cock dismounted ♀ 1YR mounted ♀ 3YB immediately and trod, then ♂ G mated ♀ 1YR as soon as the latter dismounted.

In these unisexual matings the hen assuming the male role was typically rather slow and deliberate in mounting another in a crouching position, which in many instances permitted the object of her actions to avoid. Cocks, in contrast, mounted readily and often did not pause for a hen to crouch before mounting. Apart from the fact that these hens did not court or waltz to the hens, this was probably the most notable difference between the mating behavior of these females and that of normal males. These hens grasped the comb or hackle of a hen as did the males, and also performed a treading action. They reared up, spread their tails and everted as the vents met, but unlike most males they often repeated these movements, copulating as many as five times at a single mounting. Crouching, resting, or dusting hens appeared to be a stimulus for 1YR and 1R to approach and mount. Hen 1R attempted to mount a cock in resting position, but the male arose and walked away.

Initiation of unisexual matings: No definite evidence was obtained to indicate the conditions under which the first unisexual matings arose for each of these females. As suggested above, androgen concentration in the blood, as indicated by comb size, did not appear to be a primary factor. Davis and Domm (1941) failed to obtain the masculine copulatory behavior in Brown Leghorn

poulards injected with androgens. Neither did it occur in the White Leghorn hens similarly treated by Allee, Collias, and Lutherman (1939). Zitrin (1942), however, did observe copulatory behavior in a hen during prolonged androgenic treatment. The differences in these experiments might have resulted from variations in the psychological conditions (c.f., Guhl, Collias, and Allee, 1945, p. 380).

The five hens which displayed masculine copulatory behavior were not examined for anomalies in the primary sex organs. All of them laid quite consistently and all but 1YR showed a high fertility when the flock as a whole was tested for fertile eggs.

Discussion

Unisexual matings have been observed in a number of birds and other vertebrates. A brief review of some of these has been given by Armstrong (1942, p. 138) and by Nice (1942, pp. 194-196). There are some evidences that the occurrence of such behavior may be associated with social dominance relationships, with captivity, with the caging of two or more individuals as unisexual pairs or groups. Unisexual matings appear to be rare among birds which are dimorphic species, or have well differentiated mating displays, but may occur readily under certain conditions with birds that have no plumage differences between the sexes, such as pigeons (Carr, 1919). Lack (1940) states that sexual ambivalence "is extremely complex, and probably has a different basis in different cases, sometimes genetic, sometimes hormonal, and sometimes due to various types of external situations."

Among the hens in the flock under discussion social dominance apparently facilitated pseudo-matings. However, high aggressiveness, a masculine trait, as estimated by social rank attained, was not essential. These hens failed to display the typical male courting pattern and crowing, nor did they appear to show any other outward appearance of masculinity. Davis and Domm (1941) found that either androgen or estrogen induced copulatory behavior in capons, but only androgen increased or induced crowing and waltzing. Guhl, Collias, and Allee (1945) observed crowing and waltzing in hens which did not mate. The relative dominance of masculine and feminine traits in each of the sexes and among individuals of either sex were considered by Carr (1919, pp. 97-98) in pigeons, which exhibit but little sex dimorphism.

"Certain sex characters appear to be quantitative variations of a common base rather than sharply alternative conditions. This is

especially striking with reference to sex behavior;—" (Lillie, 1939, p. 12). If one assumed that maleness was a syndrome or composite of traits with the copulatory pattern of behavior as one among several male characteristics, it might be suggested that the five hens considered above were somewhat masculine in this respect only. Certain still unknown external situations may have evoked the copulatory behavior which persisted probably as a habit in two of these individuals, 1YR and 1R. Continued observations on flocks of hens may yield some evidence as to the conditions which evoke unisexual behavior.

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Amphibians and Reptiles of Tinian Island

THEODORE DOWNS

Abstract

This paper treats of the species of reptiles and one amphibian obtained on Tinian Island, Marianas Group, together with brief observations on their habits and their diagnostic characters.

The following report is based on specimens collected and observations made by the author from May 31, 1945, to October 17, 1945, while on duty with a service group of the Army Air Forces on Tinian Island, Marianas Group, in the western Pacific Ocean. The average temperature was reported to be approximately 80° F. The humidity was high. In the later months there were heavy rains which caused considerable erosion and formed temporary rain pools. Hagoi Lake was the one fresh water lake seen on the Island. Insects outnumbered other invertebrates which included large and small land crabs, and a large number of land snails, two to three inches in diameter. The eighteen species of birds observed have previously been recorded.* Rats and mice (presumably *Rattus* and *Mus*) were the only mammals observed. Sugar cane grew on most of the lower areas. Bananas, breadfruit, and papayas grew on the slopes and hills. Tinian lacks the extensive tropical forests that occur on Saipan only three miles distant to the northeast.

Much assistance in the collecting of specimens was given by Major William B. S. Thomas, M.C. and Sgt. Eugene Cypert, Medical Department. Thanks are tendered to Dr. Edward H. Taylor for assistance in identifying the specimens and to Professor E. Raymond Hall for assistance with the present account.

FAMILY BUFONIDAE

Bufo marinus (Linnaeus)

Rana marina Linnaeus. Systema Naturae Ed. 10, 1758, p. 211.
Bufo marinus Schneider. Hist. Amph., vol. 1, 1799, p. 219.

Nos. 23396 to 23403. These and subsequent catalogue numbers are of the University of Kansas Museum of Natural History.

These large toads are unquestionably of recent introduction, but the immediate source of the introduced stock is unknown to me. The original stock came from Central or South America. *Bufo marinus* as now understood is apparently a complex of several sub-

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*Downs. Birds on Tinian, in the Marianas, Trans. Kansas Acad. Sci., vol. 49, no. 1, June, 1946, pp. 87-106.

species. The type locality is "America"; and until the group is revised it will be impossible to define the various forms more correctly.

This toad was extremely abundant. Nearly every board and stone sheltered from one to four. Hagoi lake appeared to be the center of the greatest concentration. However, toads were found at all elevations. Countless flattened individuals were seen on the roads.

The specimens obtained vary in length from 41 mm. to 112 mm. Specimens examined from various localities in Mexico, as well as those reported in the literature from Central and South America, reach a much larger size. Due to the competition between the immense numbers living on the Island of Tinian they may have become dwarfed. Possibly when older they would have attained the size maximum for the species.

A mating pair was noted on July 12, a quarter of a mile from the lake, at approximately two hundred feet elevation. On August 13, within fifty yards of the lake, another pair was clasping. On September 7, many young, tailed toads with small, fully formed legs, hopped over the forest floor, and others of this age formed a continuous ring around the edge of an isolated pool. At another time nearly two hundred adults were found isolated in a previously flooded cistern, close to the lake shore, unable to escape apparent starvation. The specimens taken were dark greenish dorsally, and reticulated and spotted with darker color on the buff venter, particularly on the throat and chest. Specimen No. 23398 contained a large mass of eggs. The eggs averaged a little more than one millimeter in diameter.

FAMILY GECKONIDAE

Hemidactylus frenatus Duméril and Bibron

Hemidactylus frenatus, Duméril and Bibron, Erpétologie Générale, vol. 3, 1836, p. 336 (type locality, Java and Timor).

Nos. 23409-23414.

The largest of these specimens measures 105 mm. in total length; the smallest is 34 mm. from snout to vent (the tail being absent.) The femoral pores of the three males vary between 26 and 30. Three of the lot are females. From the general over all darker shade at the midportion of the tail, five dark lines extend anteriorly on specimens Nos. 23412, 23413 and 23414. The two lateral lines extend anteriorly above and below the black eyes to the tip of the snout, the most ventral lines going to the extreme tip of the snout along the edge of

the upper jaw. These specimens of *frenatus* show only slight variation in structure from others of the same species found in Ceylon, the Philippines and Java with which they were compared.

Geckos were common on the walls and ceilings of the living quarters of the camp at night.

GEHYRA OCEANICA (Lesson)

Gecko oceanicus Lesson, Voyage Autour du Monde . . . sur . . . "La Coquille" Zoologie, 11, part 1, 1830, p. 42 (type locality, "Desiles d'O-Tahiti et de Boratora").

Gehyra oceanica Gray, Catalogue of the Lizards in the British Museum, 1845, p. 163.

No. 23404.

The lack of division of the sub-digital lamellar pads in *Gehyra oceanica* (Lesson) leads me to place it in *Gehyra* rather than in the genus *Peropus* as is frequently done. The latter genus possesses distinctly divided lamellar pads.

This was the largest lizard obtained. It measures 132 mm. in total length. The ventral surface of the body and tail is whitish in sharp contrast to the grayish white pigmented dorsal and lateral surfaces. There are twenty-five femoral pores. The specimen was on a papaya tree at the lake site.

PEROPUS MUTILATUS (Wiegmann)

Hemidactylus mutilatus Wiegmann, Herpetologia Mexicana, pt. I, 1834, p. 54 (corrected for *pristiurus*) p. 20 (Type locality, Manila).

Gehyra mutilata Boulenger, Catalogue of the Lizards of the British Museum, vol. 1, 1885, p. 148.

Peropus mutilatus Stejneger, Proc. U. S. Nat. Mus., vol. 21, 1899, p. 796.

Nos. 23405-23406.

The two specimens are badly mutilated on their dermal surfaces, but all identifying features are distinct. The second pair of chin-shields of one specimen is divided by a suture and the anterior portion contacts only one labial, whereas normally these shields are undivided, elongate and in contact with two labials. Dorsally the specimens are pinkish-brown, the largest one measuring 42 mm. from snout to vent. The tails of both specimens are lost. Thirty-two femoral pores are present in each specimen.

FAMILY SCINCIDAE

EMOIA WERNERI (Vogt)

Lygosoma cyanurum Boulenger, (part) Catalogue of the Lizards in the British Museum, vol. 3, 1887, p. 290.

Lygosoma cyanurum werneri Vogt, Sitzungsber. Ges. Naturf. Freunde Berlin 1912, pp. 5-6 (type locality, Mariana or Ladrone Islands).

Nos. 23415-23432.

Emoia werneri (Vogt) differs from *Emoia cyanura* (Lesson) in the number of lamellae under the fourth toe and in other less distinctive characters, which place all of the specimens from Tinian in *Emoia werneri* (Vogt). The following table presents a summary of several comparable features:

Emoia werneri (Vogt) Cat. No.	Longitudinal scale rows	Scales from occiput to base of tail	Lamellae under the fourth toe	Total length
23415	53	29	38	120
23416	57	29	40	114
23417	56	28	38	95
23418	57	28	44	122
23419	56	29	40	126
23420	57	29	39	102
23421	57	29	33(?)	119
23424	57	29	38	102
23425	54	28	39	104
23426	57	29	35	121
23427	53	28	40	119
23428	56	28	36	120
23429	57	28	40	115
23430	56	29	37	100
23431	53	29	39	80
23432	53	29	38	76
Summary	53-57	28-29	35-40	76-126

Longitudinal scale rows were counted at a point where the tip of the fourth finger touches the body when the arm is adpressed. The scales from the 'occiput to the base of the tail' include the scales from the parietals to the row of scales directly in line with the vent. The lamellae are counted from the point of free articulation of the digit starting with the first broadened scale of the ventral surface through the last wide lamella at the base of the claw. The younger specimens have bright blue tails and three distinct light longitudinal lines, extending from the snout to the tail. Other specimens are all-over brown.

These skinks were found over much of the island, but were especially numerous near the lake, where, at times, the trees seemed alive with moving lizards. Several ran over my body and on to a nearby limb in diligent search for food. They frequented rubbish piles and were occasionally seen on the frame structures in the group areas. They were found commonly also on the ground, scurrying under leaves or logs. This was the most abundant species of reptile seen.

FAMILY TYPHLOPIDAE

TYPHLOPS BRAMINUS (Daudin)

Eryx braminus Daudin, Histoire Naturelle des Reptiles, vol. 7, 1803, p. 279 (type locality, Bengal, India).

Typhlops braminus Cuvier, Règne Animal, 1829, 2 ed., p. 73.

Nos. 23407-23408.

This blind snake seemed uncommon and occurred under partly buried rocks and boards in the areas of lower elevation. The general coloring is dark brown dorsally and light pink ventrally. The larger of the two specimens measured 90 mm. in length. There are twenty rows of scales around the body and 322-324 scales from head to the tail. The specimens were collected by Major Thomas and Sergeant Cypert. These closely resemble the *T. braminus* of India, Malaya and the Philippines which I examined, except that those from Tinian are somewhat smaller.

The species of reptiles now found on Tinian could easily have been transported there by natural means. They are unspecialized in food requirements. The small number of full species, each with few or no profound anatomical differences from its Asiatic ancestor supports the theory that the Tinian fauna is of comparatively recent age geologically.

Kansas and the Geodetic Datum of North America

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Kansas has the distinction of having within its borders two significant landmarks. One of these is the geographical center of the United States, the other is the Meades Ranch triangulation station or the geodetic datum known as the North American datum of 1927. Of the two landmarks the North American datum of 1927 is of the greater importance as will be discussed below.

The geographical center of the United States is about 1 mile north and 1 mile west of Lebanon in the SE ¼, sec. 32, T. 2 S., R. 11 W. in Smith county. (Schoewe, 1940, p. 305). Its geographical coordinates are 39° 50′ North latitude and 98° 35′ West longitude. (Deetz, 1918, p. 57) The geographical center "may be defined as that point on which the surface of the area would balance if it were a plane of uniform thickness, or in other words, the center of gravity of the surface." (Douglas, 1939, p. 253) It should be stated that there is no entirely satisfactory method of determination of a geographical center of any state, county, or continent (Adams, 1932, p. 586) and that therefore there is no officially marked point established at the geographical center of the United States. (U. S. Geological Survey, Mimeographed Circular 22164) The monument erected by the Hub Club of Lebanon in Smith county at the instigation of the Kansas Academy of Science and dedicated on June 29, 1941 as marking the geographical center of the United States may be considered for all practical purposes in its correct position although the intersection of latitude 39° 50′ with longitude 98° 35′ determined by the U. S. Coast and Geodetic Survey as the position of the geographical center lies approximately 2,270 feet northwest of the monument.

Location and description of geodetic datum.—Meades Ranch triangulation station or the geodetic datum known officially as the North American datum of 1927 is in Osborne county at a place 8 miles east and 14½ miles south of the intersection of county road 388 with K. 8 in the east part of Osborne, the county seat. More specifically, this important landmark is in the SE. ¼, SE ¼, NW. ¼, SW. ¼, sec. 34, T. 9 S., R. 11 W. (detailed location determined by Schoewe from description of Meades Ranch station, U. S.

Coast and Geodetic Survey, Description of Triangulation Stations, p. 5, T. 75-31) on pasture land (Fig. 1a) known as Meades Ranch owned formerly by Dr. Moore of Lucas in Russell county, but now, according to Mr. E. A. Ford, Register of Deeds, Osborne county, in the possession of Mr. Frank Robinson also of Lucas. Its geographical coordinates as determined by the U. S. Coast and Geodetic

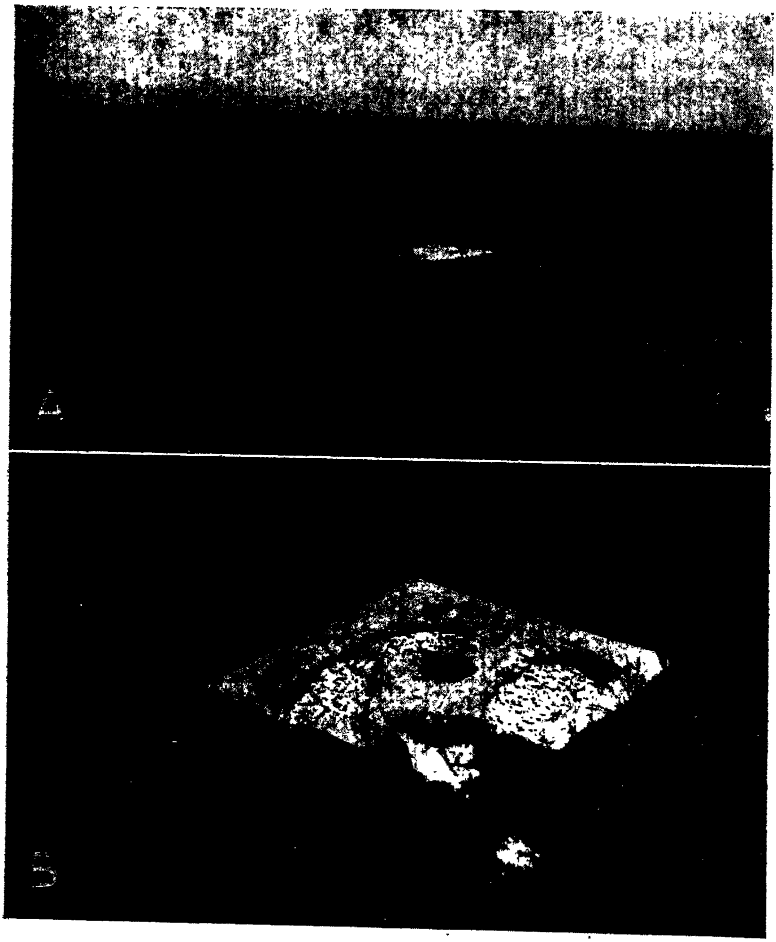

FIGURE 1.

(A) General view of the North American datum of 1927 on pasture land known as Meades Ranch and owned by Frank Robinson of Lucas in the SW¼ sec. 34, T. 9 S., R. 11 W. in Osborne County Kansas, 39° 13′ 26.686″ North latitude, 98° 32′ 30.506″ West longitude.

(B) Close-up view of the North American datum as seen on August 11, 1947. Sides of the station marker coincide with cardinal directions with SE corner toward observer. Station marker to be repaired according to Director of the U. S. Coast and Geodetic Suvey.

Survey are: 39° 13′ 26.686″ North latitude and 98° 32′ 30.506″ West longitude, Azimuth to Waldo triangulation station 75° 28′ 14.52″. (U. S. Coast and Geodetic Survey, 1941, p. 14). The site of this geodetic datum is marked at present (August 11, 1947) by a concrete slab 25 inches square which projects several inches above the ground (Fig. 1b). In the center of the slab is imbedded a circular bronze disk inscribed, "U. S. Coast & Geodetic Survey, Meades Ranch, 1891."

According to C. K. Green, Acting Director of the U. S. Coast and Geodetic Survey in a letter to me dated January 13, 1948, the station originally "was marked with a bottle filled with ashes buried approximately three feet under the ground level and a six-inch square marble post with top flush with the surface with the letters U. S. C. S. and two grooves at right angles to each other cut in it. The intersection of the two grooves was vertically in line with the neck of the bottle and indicated the center of the station." In 1922 the station was remarked as follows: "The underground mark is a standard bronze station tablet, set in a block of cement 34 inches below the surface. Station mark is a similar tablet, set in the center of the top of a block of concrete 36 inches square at the base, 24 inches square at the top, and 3 feet high, projecting 6 inches above the surface. A 2-inch layer of sand separates the concrete blocks. The name of the station and date of establishment, is stamped on each mark. Two standard bronze reference tablets, set in stone posts, are 2.652 meters (8.70 feet) north and 2.627 meters (8.62 feet) south from the station and about 1 inch below the surface. Additional references are as follows: North and south fence on east line of Dr. Doan's lands, a wire fence with large stone posts 2 rods apart, 72.2 meters (237 feet); east and west fence on south line of section 34,469.7 meters (1.541 feet) south; stone marking southwest corner of section 34,571.35 meters (1874.5 feet) in Azimuth 34° 33′ ″. (U. S. Coast and Geodetic Survey, Descriptions of Triangulation Stations, p. 5, T. 75-31) In 1934 the station was recovered by a concrete block whose top measured 25 inches square instead of 24 inches.

Importance of geodetic datum.—Unlike the geographical center which is of great public interest as evidenced by the thousands of visitors who have recorded their presence in the registration book at the monument site but which has no practical or scientific significance, the geodetic datum is of utmost practical and scientific value. It is the point of origin for all Federal mapping in the United States

as well as in Canada and Mexico. In the surveying and mapping of extensive areas where accurate knowledge is required of the horizontal relationship between points on the earth's surface the exact curvature of the sea level surface of the earth as well as the shape and size of the earth must be taken into account. All points on the earth's surface can be located accurately only on the basis of their geographic coordinates or latitudes and longitudes. The determination of these geographic coordinates is the function of geodetic surveying which also includes ascertaining their elevations and establishing the shape and size of the earth. The horizontal control for all of these measurements is accomplished by a system of triangulation which today in the United States consists of an extensive network of triangles and quadrilaterals involving about 12 east-west arcs of triangulation and 30 north-south arcs. (U. S. Coast and Geodetic Survey, 1941, p. 1) This elaborate network of triangulation contains tens of thousands of control points all of which are definitely established, marked and monumented and all of whose latitudes and longitudes are now known. These thousands of control points are all coordinated with the geodetic triangulation station or datum on Meades Ranch in Osborne county and serve as the control points for the various types of surveys—topographic, geologic, hydrographic, those needed in engineering construction and others—in every state in the United States.

Geodetic datum defined.—A geodetic datum is a selected point on the earth's surface whose position (latitude and longitude) has been determined on the basis of an adopted spheroid of the earth, which is taken to represent the earth's shape, and whose azimuth of the direction to another triangulation station is known. The relative positions of all other points in the entire survey are directly related to the geodetic datum and therefore it is possible to calculate and to coordinate the latitude and longitude of any triangulation point in the triangulation system.

Need for a single datum.—Since a given point on the earth's surface can have but one latitude and longitude which must be the same on every map or chart on which it appears it is necessary that there should be only a single horizontal datum for the triangulation points in the country. Meades Ranch triangulation station in Osborne county was the one chosen for that purpose by the United States Coast and Geodetic Survey for the United States.

Date of selecting the single datum.—The Meades Ranch triangulation station in Osborne county officially became the geodetic datum

for the United States in 1901. (Sharp, 1940, p. 62) Previous to 1899 there was no single geodetic datum in the United States. Triangulation in this country first started in 1817 in the vicinity of New York. Subsequently other triangulation surveys came into existence. These surveys were made in various parts of the United States between the Atlantic and Pacific coasts, entirely unrelated and each one based upon its own geodetic datum. It was not until the various independent triangulation systems expanded and overlapped that it was possible to coordinate all of the surveys on to a single datum. After the transcontinental triangulation system had been developed geographic positions were computed through the chain of triangles on what was known as the New England datum in the northeastern and eastern part of the United States. After computing the transcontinental triangulation in 1899 this datum was adopted for the whole country. Meades Ranch triangulation station was first established in 1891 as one of many in the transcontinental triangulation arc stretching from the Atlantic to the Pacific coast.

Reasons for selecting the Meades Ranch station for the geodetic datum for the United States.—The Meades Ranch triangulation station is approximately 40 miles due south of the geographical center of the United States and is at the junction of two great arcs of triangulation, one along the 39th parallel and the other along the 98th meridian. (Colbert, 1947, p. 377) Partly because of the relation of the Meades Ranch station to the geographic center of the United States and to the two great arcs of triangulation the Osborne county triangulation station was selected as the geodetic datum for the United States. (Colbert, 1947, p. 377) This was done in 1901. However, of greater importance in its selection than the two factors just mentioned is the fact that at the time of the adoption of the datum all available astronomic positions which were connected with the triangulation net of the United States checked unusually well with their corresponding geodetic positions. (U. S. Coast and Geodetic Survey, 1941, p. 14) The importance of this close agreement between astronomic and geodetic determined positions becomes apparent when it is realized that large mountain masses or other topographic features deflect the plumb line laterally and therefore cause arcs of triangulation to swerve away from their true orientation. Stated otherwise, positions of selected points determined astronomically do not necessarily agree with the positions of the same points as determined by geodetic methods. The ideal datum therefore is one in which the differences between the geodetic and astro-

nomic determined positions are in close agreement. After exhaustive study by the U. S. Coast and Geodetic Survey it was concluded that the position for Meades Ranch station was as accurate as could be determined. (Green, 1948, personal communication)

International datum—North American datum.—In 1913 Canada and Mexico adopted the Meades Ranch datum which was officially designated the United States Standard datum in 1901 as their geodetic datum and by doing so made possible the coordination of all geodetic triangulation surveys on the North American continent controlled by a single geodetic datum. As a result of the international adoption of the single geodetic datum there exists today in North America the largest arc of continuous triangulation in the world. (Colbert, 1947, p. 377) Since Meades Ranch station now served the entire North American continent as point of origin for all triangulation systems, its name, United States Standard datum, was officially changed to North American datum.

North American datum of 1927.—As pointed out elsewhere in this paper the shape and size of the earth must be considered in determining the exact position of the geographic coordinates of any point on the earth's surface. From many precise measurements the shape of the earth has been determined as an oblate spheroid or ellipsoid or a spheroid of revolution whose polar diameter is about 27 miles less than its equatorial diameter. Several spheroids of revolution (Table 1) have been computed and since the beginning of the nineteenth century the earth's dimensions have been computed with considerable accuracy at least twenty times. (U. S. Coast and Geodetic Survey, 1941, p. 13) Of the spheroids the Bessel spheroid of 1841 and the Clark spheroid of 1866 have been used most extensively. The United States Coast and Geodetic Survey used the Bessel spheroid for its standard until 1880, when it adopted the Clark Spheroid of 1866 as being better suited for its needs. In 1922 the International Union of Geodesy and Geophysics (International Geodetic Association) meeting in Rome, Italy proposed that a standard figure or spheroid of the earth should be adopted for use in the publication of geodetic results for the entire world and that the standard or universal spheroid should be selected at the next meeting of the Union to be held two years later. At the Madrid, Spain meeting of the Union held in October 1924, the Hayford spheroid of 1910 was adopted as the International spheroid. (Hinks, 1944, p. 234) The Hayford spheroid is based on dimensions derived in 1909 by John F. Hayford, who was at that time a member

of the United States Coast and Geodetic Survey. (U. S. Coast and Geodetic Survey, 1941, p. 13) The United States Coast and Geodetic Survey, however, continued to use the Clark spheroid of 1866 as its standard spheroid of revolution chiefly because at the time the International Union adopted its reference spheroid, many thousands of triangulation stations based on the Clark spheroid were in existence in the United States and numerous computation tables based on the Clark spheroid had been published. It was felt that because of the facts just mentioned and the great amount of work involved in changing to a new spheroid, especially since the Clark spheroid differed only slightly from the Hayford or International spheroid (Table 1), the change was not fully justified. (U. S. Coast and Geodetic Survey, 1941, p. 13)

In 1927 it became necessary to recompute the national control net. In the re-adjustment the positions of all triangulation stations were changed except the one on Meades Ranch in Osborne county. In the vicinity of the Meades Ranch station or the North American datum the changes in position were small but became larger as distances from the datum increased. In the state of Washington the positions of triangulations changed as much as 1 second in latitude and nearly 1.4 seconds in longitude. (U. S. Coast and Geodetic Survey, 1941, p. 15) In order to avoid confusion in designating the new positions for the triangulation stations of the national control net from their previous position the name North American datum was changed to North American datum of 1927.

Recent developments.—According to recent reports in the newspapers (Andrews, 1948, p. 12; Kansas City Times, Jan. 19, 1948) the United States Coast and Geodetic Survey has started a project to recompute the size and shape of the earth, a project which also is being undertaken by the Soviet Union. The recent World War with its rocket and other modern long-ranged missile warfare methods has demonstrated the need for more accurate knowledge of geographic positions on the earth's surface. It is expected that the information obtained will furnish military firing experts with data of incalculable strategic importance. At present calculations of the earth's diameter vary according to different computers. (Table 1) It is hoped that the new calculations will reduce greatly the margin of error in the pole-to-pole measurements which is as much as 1 mile in some measurements, to less than 600 feet. Since Meades Ranch station or the North American datum of 1927 is the geodetic datum to which all triangulation systems on the North American continent

are based, all measurements for this new project will be controlled by this Kansas station.

Table 1.—Earth spheroids, radii and ellipticities (Hinks, 1944, pp. 230, 232; U. S. C. & G. S., 1941, p. 14)

Spheroid	Earth Radii in Meters: Equatorial (a)	Earth Radii in Meters: Polar (b)*	Differences in Radii a & b*: Meters	Differences in Radii a & b*: Miles	Flattening or Ellipticity $\frac{a-b}{a}$
Everest 1830	6,377,304	6,356,102.9	21201.1	13.17	1:300.8
Bessell 1841	6,377,397	6,356,082.2	21314.8	13.24	1:299.2
Airy 1849	6,377,542	6,356,233.9	21308.1	13.24	1:299.3
Clarke 1858	6,378,294	6,356,655.2	21638.8	13.44	• 1:294.3
Clarke 1866	6,378,206.4	6,356,583.8	21622.6	13.43	1:294.98
Clarke 1880	6,378,249	6,356,517.3	21731.7	13.50	1:293.5
Hayford or International 1910	6,378,388	6,356,911.9	21476.1	13.34	1:297
McCaw 1924	6,378,300	6,356,752.0	21548.0	13.39	1:296

*Computed by W. H. Schoewe.

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Ground Waters Available for Water-Flooding Oil Projects in Southeastern Kansas[1]

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Water for flooding oil formations, known as injection water, is either fresh water from surface ponds or streams, shallow water wells, and municipal supplies or salt waters from an underground source. In southeastern Kansas the salt water or brines are commonly obtained from the Mississippian and Ordovician (Arbuckle) rocks. In some projects the supply of water is limited to water associated with the oil in the oil reservoir; however, in most projects the water obtained from the oil wells is mixed with an additional supply which may be either fresh water or a brine. In Kansas there are 24 water repressuring projects using fresh water and 30 using brines.

Precipitation is the source of all fresh water supplies. A very important characteristic of precipitation in southeastern Kansas is its variability. Some years bring higher than average precipitation and others much lower than average. While the chemical characteristics and turbidity of river water vary within wide limits, supplies of fresh water for water-flooding projects can be found at many places in the Verdigris or Neosho valley drainage basins from reservoirs, streams, or shallow wells in alluvial deposits.

Abundant supplies of salt water or brines suitable for water-flooding can be obtained in southeastern Kansas from drilled wells. The quantity of water that can be obtained from ground-water reservoirs of southeastern Kansas depends upon the area, thickness, porosity, and saturation of the reservoirs and upon the permeability —the rate that water will pass through the pore spaces or openings in the rock.

The openings in the ground-water reservoirs of southeastern Kansas are of two types. One type comprises small cavities or pore spaces in the rock; the other type comprises cracks, fissures, and solution channels.

Porous beds of rock that are the chief reservoirs for ground water are exposed at the surface in southwestern and southcentral Missouri along the axis of the Ozark Uplift, where water enters

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[1]Read before the Kansas Academy of Science at the Lawrence meeting April 3, 1947. Published by permission of the Director of the Kansas Geological Survey.

[2]State Geological Survey of Kansas.

these beds from local rainfall. The altitude of the intake area in Missouri ranges from about 800 feet (the minimum elevation of areas of the Cherokee surface rocks) to a maximum elevation of 1800 feet (outcrop areas of the older Ordovician rocks). The chief ground water zones in southeastern Kansas range from a few hundred feet to 2000 feet or more in depth. The water wells in southeastern Kansas are artesian wells in which the water is under sufficient hydrostatic pressure to flow from the well or rise in the well to a height above the local water table. A few wells have been known to flow; however, in most wells the water does not flow from the well, but in some areas rises several hundred feet above the point at which it is first encountered. The rise of the water level in the well reduces the pumping cost by reducing the foot-pounds of energy required to lift the water from its position in the well to the surface of the ground.

The chief water-bearing rocks of southeastern Kansas are, in ascending order, the Lamotte sandstone (Upper Cambrian), Roubidoux sandstone (Lower Ordovician), Jefferson City-Cotter dolomites (Lower Ordovician), Keokuk-Burlington and Warsaw limestones (Mississippian), and sandstones in the Cherokee (Pennsylvanian).

The yield of water from wells that tap these formations, if pumped continuously, ranges from 150,000 to more than 2,000,000 gallons a day, and continuous supplies of 500,000 to possibly as much as 8,000,000 gallons a day are available from groups of properly constructed and properly spaced wells.

Mineral Content of Deep Well Ground Waters

Chemical analyses show that deep well waters in southeastern Kansas have a considerable range in quality; however, the mineral content of water from a water bearing rock becomes progressively greater with the westward distance from the outcrop area in Missouri and progressively greater with increased depth of the water bearing rock below the surface. The mineral content of the water from any single ground-water reservoir is remarkably uniform in one area provided the water has not been mixed with the water from some other reservoir.

The Lamotte sandstone.—The Lamotte sandstone is the deepest formation that yields large quantities of water in southeastern Kansas. It is of Upper Cambrian age and overlies pre-Cambrian granite. It ranges from 44 to 140 feet in thickness in wells that have penetrated the formation in southeastern Kansas. It is exposed at

the surface in southeastern Missouri and lies near the surface in an area surrounding the St. Francis Mountains, where it is charged with water from local rainfall.

Table 1.—Analyses of water from the Lamotte sandstone in southeastern Kansas

(in parts per million)[3]

Well	Harley No. 1	Wert No. 1
Location	SE¼, NE¼ Sec. 30, T.31 S., R.22 E.	NE¼, SE¼ Sec. 17, T.31 S., R.21 E.
Depth to top of Lamotte	1787 feet	1822 feet
Sea level elevation top of Lamotte	−897 feet	−966 feet
Sodium (Na)	9,121	24,820
Calcium (Ca)	1,465	6,700
Magnesium (Mg)	523	975
Sulphate (SO_4)	1,140	1,180
Chloride (Cl)	17,220	52,100
Bicarbonate (HCO_3)	214	101

[3]Abernathy, G. E., State Geological Survey of Kansas, Bulletin 38, Part 8, p. 227, 1941.

Roubidoux formation.—The Roubidoux is the next important water-bearing formation above the Lamotte sandstone. It crops out in southern Missouri in a large area where water may enter the formation. Its exposures are to be found in almost every county in the Ozarks[4]. The formation is composed of alternating beds of dolomite and sandstone. Because of its sandstone content and resultant porosity and the impervious beds that lie above it, it is the most important water-bearing formation in southeastern Kansas and northeastern Oklahoma. In the Tri-State district of Oklahoma, Kansas, and Missouri, it is the most common source of fresh water for municipal and industrial supply. Its thickness in wells that have penetrated the formation range from 90 to 160 feet. In most of southeastern Kansas, it ranges from 600 to 750 feet below the top of the Mississippian limestone and consists of sandy dolomite and two beds of sandstone. The uppermost sandstone is about 15 feet thick and occurs in the middle of the formation. The lower sandstone is 25 feet thick and occurs at the base of the formation. The analysis of the cuttings from the formation of a well drilled at the Jayhawk Ordnance Works in Cherokee County indicated the average solubility of the dolomite in the formation was 74.82 percent, the upper sandstone member 18 percent, and the lower sandstone member 10 percent. It is difficult to get an analysis of water that is exclusively Roubidoux formation water due to the fact that most of the wells are not cased below the top of the Mississippian; therefore this water is a composite of all the water from pre-Mississippian reservoirs penetrated by the well. The following table gives the

[4]Bridge, Josiah, 1930, Geology of the Eminence and Cardareva quadrangles: Missouri Bur. Geol. and Mines, 2d ser., vol. 24, pp. 1-228.

chemical analyses of water from three wells where all waters except those from the Roubidoux formation were cased off.

Table 2.—Analyses of water from the Roubidoux formation[5] (Other waters excluded by casing.)

(in parts per million)

	Water Well at Jayhawk Ordnance Works Sec.4,T.34S.,R.25E.	Water Well at Baxter Springs Sec.1,T.35S.,R.24E.	Water Well at Columbus Sec.13,T.33S.,R.23E.
Total Hardness	169.0	183.0	193.0
Carbonate Hardness	140.0	148.0	193.0
Non Carbonate Hardness	29.0	35.0	.0
Alkalinity as $CaCO_3$	140.0	148.0	359.0
Ca	38.0	42.0	41.0
Mg	18.0	19.0	22.0
Na	15.0	52.0	121.0
HCO_3	170.0	181.0	438.0
SO_4	31.0	25.0	35.0
Cl	20.0	85.0	39.0
NO_3	1.2	1.8	---- --
SiO_2	9.2	7.4	6.0
Fe	0.38	0.32	0.0
Fluorine	0.5	0.2	1.3
Total Solids	227.0	340.0	477.0
Turbidity	10.0	0.0	10.0

[5]Analyses by Kansas State Board of Health.

Cotter dolomite.—The Cotter dolomite lies between the Chattanooga shale above and the Jefferson City dolomite below. The thin Swan Creek sandstone, if present, occurs at its base. An abundant supply of ground water occupies solution cavities and a porous zone that occur near the top of the Cotter formation. The water usually contains appreciable amounts of hydrogen sulphide; however, the hydrogen sulphide can be removed by a simple process of aeration. The water is appreciably softer than the water in the Mississippian rocks above and also appreciably softer than the water in the underlying Jefferson City dolomite.

Table 3.—Analyses of water from the Cotter dolomite.

(in parts per million)

	Location of Well	
	Sec.4,T.34S.,R.25E.[6]	Sec.17,T.35S.,R.17E.[7]
Total Hardness	212.0	---- ----- --
Carbonate Hardness	184.0	---- ----- --
Non Carbonate Hardness	28.0	---- ----- --
Alkalinity as $CaCO_3$	184.0	---- ----- --
Ca	24.0	469.0
Mg	37.0	163.0
Na	31.0	5,800.0
HCO_3	215.0	662.0
SO_4	35.0	30.0
Cl	40.0	9,842.0
NO_3	1.1	---- ----- --
Fe	0.44	---- ----- --
Fluorine	0.4	---- ----- --
Total Solids	306.0	16,966.0
Turbidity	10.0	---- ----- --

[6]Abernathy, G. E., Kansas Geological Survey Bull. 47, Part 3, 1943, p. 105.
[7]Analysis reported by Gulf Oil Co.

[8]Lee, Wallace, Relation of Thickness of Mississippian Limestones in Central and Eastern Kansas to Oil and Gas Deposits, Kansas Geol. Survey, Bull. 26, p. 10, 1939.

Mississippian limestone.—The Mississippian limestone has a uniform thickness of 300 to 450 feet in southeastern Kansas.[8] The Mississippian rocks in southeastern Kansas contain abundant supplies of ground water.

The water in the Mississippian is derived from rainfall entering the formations at outcrops farther east in Missouri. The water occurs at formational contacts and in porous and fracture zones. Ground water charged with dissolved carbon dioxide has dissolved large quantities of soluble minerals from these rocks and formed extensive systems of water courses and porous zones. The occurrence of fractures and solution openings is very irregular, making it difficult to predict where water will be found in the Mississippian rocks. However, contact zones are favorable places. The ground water in Mississippian rocks is normally high in its carbonate, sulphate, and iron content and is commonly classed as corrosive water. Table 4 is typical of its chemical composition.

Table 4.—Analyses of water from the Mississippian rocks

(in parts per million)

	Location of Wells			
	Sec.4,T.34S., R.25E.[9] Burlington-Keokuk Formation	Sec.4,T.34S., R.25E.[9] Reeds Spring Formation	Sec.8,T.28S., R.11E.[10]	Sec.9,T.28S., R.12E.[10]
Total Hardness	622.0	546.0	----	----
Carbonate Hardness	315.0	138.0	----	----
Non Carbonate Hardness	307.0	408.0	----	----
Alkalinity as $CaCO_3$	315.0	138.0	----	----
Ca	328.0	184.0	4,731.0	3,429.0
Mg	6.8	21.0	1,791.0	2,162.0
Na	17.0	26.0	33,860.0	29,608.0
HCO_3	384.0	324.0	27.0	15.0
SO_4	----	----	4.0	0.0
Cl	4.0	12.0	65,786.0	58,016.0
NO_3	1.1	0.75	----	----
SiO_2	81.0	22.0	----	----
Fe	1.7	0.94	----	----
Fluorine	0.2	0.2	----	----
Total Solids	951.0	860.0	106,199.0	92,230.0

[9] Abernathy, G. E., Kansas Geological Survey Bull. 47, Part 3, 1943, p. 105.
[10] Analysis reported by Gulf Oil Co.

Pennsylvanian rocks.—The sandstone beds of the Cherokee are reservoirs for ground water in many places in southeastern Kansas. They are, in ascending order, the "Burgess sand," "Bartlesville sand," "Burbank sand," and "Squirrel sand." The "Burgess sand" and the "Bartlesville sand" are widely distributed over the extreme southeastern portion of the area; however, most of the sandstones in the Cherokee are lens-shaped bodies.

Other Pennsylvanian sandstone beds that are reservoirs for ground water are sand lenses that occur near the base of the Bourbon and the top of the Marmaton rocks and also sand lenses near the base

of the Douglas and the top of the Pedee rocks, called the "Big Salt sand," which are at a depth of about 1000 feet in Greenwood County. The analyses of water from sandstone water reservoirs in Greenwood County are found in table 5.

Table 5.—Analyses of water from Pennsylvanian sands

(in parts per million)

	Location of Wells		
	Sec.8,T.26S.,R.5E.[11]	Sec.28,T.25S.,R.5E[11]	Sec.26,T.28S.,R.10E.[12]
Na	61,560.0	60,786.0	----
Ca	2,090.0	8,890.0	----
Mg	2,560.0	3,200.0	----
SO_4	----	----	304.0
Cl	106,080.0	118,560.0	42,217.0
HCO_3	68.0	63.0	128.0
Total Solids	172,418.0	191,517.0	42,649.0

[11]Fath, A. E., State Geological Survey of Kansas, Bull. 7, p. 175.
[12]Reported by Gulf Oil Co.

Sandstone formations are commonly shot to increase the rate at which the formations "take" water. The amount of nitro used per foot of sand in each well on water-flooding projects in southeastern Kansas ranges from one to four quarts. Many sandstones have tight and porous streaks or a wide variation in permeability, so that water will not flow through them at uniform rates.

A major requirement for successful water-flooding is an adequate supply of suitable water. The chemical characteristics and turbidity of river waters in southeastern Kansas vary greatly with the rainfall. Fresh waters usually contain organic matter which can be removed by treatment with chloride of lime before the water is injected into an oil sand. The water treatment problem for fresh water is therefore of considerable importance. Ground water is very uniform in chemical composition and the necessary treatment required before it can be injected usually need not be changed other than over long periods of time.

Some Effects of Burning Upon a Prairie in West-Central Kansas

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INTRODUCTION

Although burning of pastures is not generally practiced in this part of the country, fires are quite often started accidentally and may burn over considerable area before being brought under control. These fires are quite often taken for granted with little thought of actual damage done. Such a fire occurred in the College Pasture west of Hays, Kansas, on November 22, 1944, burning off about one-half of the pasture. Then on March 27, 1945, another fire of similar origin swept across the pasture burning off most of the remaining vegetation.

This pasture has been described by Albertson [1] as comprising approximately 750 acres of mixed prairie, which is made up of three general habitats. The short grass habitat is characterized by a predominance of buffalo grass (*Buchloe dactyloides*) and blue grama grass (*Bouteloua gracilis*). The little bluestem habitat, occurring principally on hillsides, supports many species the most abundant of which are side-oats grama (*Bouteloua curtipendula*), big bluestem (*Andropogon furcatus*), and little bluestem (*Andropogon scoparius*). The lowland habitat is dominated at present by western wheat grass (*Agropyron smithii*) with some of the other mesic grasses such as big bluestem, wild rye (*Elymus canadensis*), and switchgrass (*Panicum virgatum*) present in local areas. Also included in the pasture is an 80 acre tract which was abandoned from cultivation in 1920 and is now being revegetated by natural means. This habitat consists of a rather even stand of sand dropseed (*Sporobolus cryptandrus*) with islands of buffalo grass one to several feet in diameter scattered throughout. In spite of the fact that conditions were not controlled experimentally, these fires offered an opportunity to study the effects of burning with fall burned, spring burned, and unburned areas sometimes lying adjacent to each other. The purpose of this paper is to present data on the detrimental effects of pasture burning and the rate of recovery through two seasons of growth.

Apparently no work has been published on the effects of burning on this type of prairie. Elwell, Daniel, and Fenton [4], working near

Guthrie, Oklahoma, found that annual burning caused a loss of nitrogen, destroyed organic matter, and increased soil and water losses. In South Africa, Staples [7] found fire, if managed properly, to be effective in maintaining or encouraging a desirable stage in plant succession. Burning during the period of active growth caused considerable damage by producing undesirable changes in the vegetation and reducing the cover. Graber [5] reported serious reductions in the yield of bluegrass after burning off old growth. Damage was more severe when the vegetation was burned after the ground had thawed than while it was still frozen. Late burning greatly increased the growth of weeds.

Aldous [2], working in the bluestem pastures of eastern Kansas where burning is generally practiced, made studies on effects of burning at different times of the year. Burning decreased the yield of mature vegetation, but did not cause any decrease in the organic matter or total nitrogen during a five-year period. The yield was least on the plots burned in late fall. Edwards [3] reported that periodic burning in the dormant season helps maintain a good composition in East Africa. However, if an area containing excessive debris is burned, it will result in marked and undesirable changes in the vegetation. Observations made by Pickford [6] on foothill range in Utah indicated that burning had a tendency to decrease the density of perennial grasses and increase the annual grasses.

METHODS

In the highland short grass habitat 5 meter square quadrats were laid out in the fall burned area and 5 in the spring burned area. Some of these quadrats were pantographed in the spring of 1945 charting both dead crowns and live growth to determine which species had been most severely damaged. They were all photographed in the fall of 1945 and 1946. The quadrats were also clipped periodically and the air-dry forage weighed and converted to a pounds per acre basis. Similar studies were made in the natural revegetation, little bluestem, and lowland habitats. Not in all cases, however, were fall and spring burned areas available for comparison studies.

Because of light grazing during former years, excessive litter had accumulated over much of the pasture. Some of this litter had been removed from a small area of short grass which had been fenced in 1942. Quadrats were laid out in areas of light and heavy accumulation in order to study the effects of burning under these conditions

RESULTS

Short Grass Habitat—Fall and Spring Burned

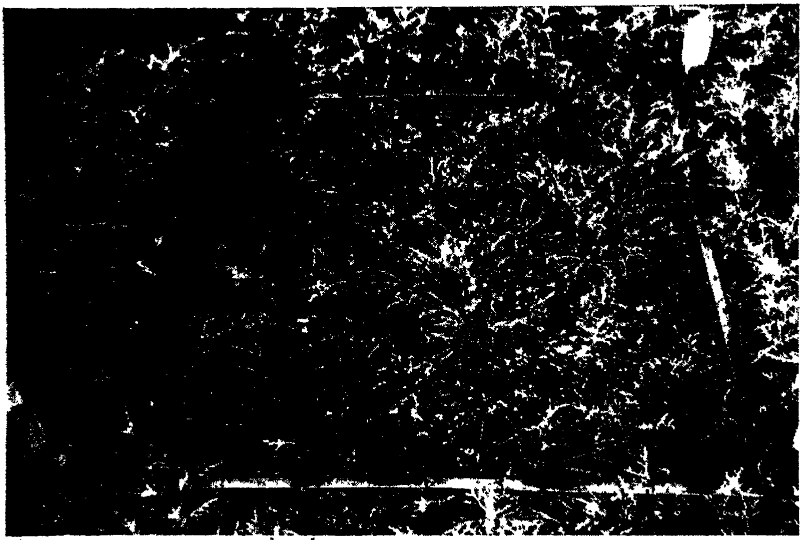
By April 19 very little growth of grasses had occurred on the area burned over the previous month, while in the adjacent area burned the preceding fall, growth of grasses was well started and had an average height of 1.2 inches. On May 22 estimates were made as to the average amounts of cover lost. After fall burning, buffalo grass was found to have suffered a loss of about 25 percent and blue grama grass 50 percent of their previous covers. In the spring burned area both blue grama and buffalo grass lost 45 to 80 percent with the former species generally being the most severely damaged (Fig. 2). Exact losses of quadrats pantographed are shown in Table I. Total basal cover after one season's growth was 62 percent in the fall burned area and only 20 percent in the spring burned area (Table II). Corresponding seasonal yields of palatable forage were 1918 and 635 pounds per acre, respectively, in the two areas.

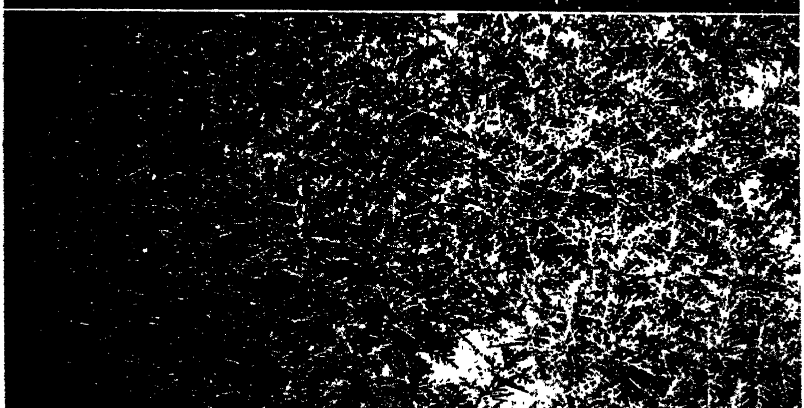
Table I.—Percent basal cover before and after burning and percent loss of five important species.

	Short Grass Habitat		Little Bluestem Habitat		
	Buffalo grass	Blue grama	Side-oats grama	Big bluestem	Little bluestem
Before fire	76.2	11.8	6.3	13.3	4.7
After fire	39.4	3.9	5.3	12.0	3.1
Percent loss	48.3	66.9	15.8	9.7	34.0

On May 22 there was a definite aspect of various shades of wild onion (*Allium nuttallii*) in the fall burned area but it ceased abruptly at the line between the two areas as the wild onions had been severely damaged by spring burning. The most abundant forb in the short grass habitat was perennial ragweed (*Ambrosia psilostachya*). This plant started later but soon became more abundant and larger in the spring burned than in the fall burned area. Total yield of forbs was 451 and 1210 pounds per acre, respectively, on the fall and spring burned areas.

By the fall of 1946, the basal cover in the fall burned area had increased to 73 percent while the spring burned area had a cover of 44 percent. The latter had more than doubled its cover in the second year of growth after the fire but was still considerably below a normal cover. Yields on the fall and spring burned areas were 733 and 618 pounds per acre, respectively, with the decrease from last year probably due in part to insufficient rainfall during the growing season. Ragweeds were held in check by the drought, yielding less





than 100 pounds per acre on both areas. This figure is conservative, however, in that some of these forbs had dried up and broken off before the clippings were made.

Short Grass Habitat—Light and Heavy Litter

Where litter was heavy at the time of burning, damage was severe and the live cover was reduced by more than one-half to a basal cover of only 44 percent. This area produced 1080 pounds of air-dry grass per acre and almost the same amount of unpalatable forbs in 1945 (Table II) (Fig. 3). Where the litter was light at the time of burning, the basal cover was 95 percent, the yield of grass was 2709 pounds, but the yield of forbs was only 130 pounds per acre.

By the fall of 1946, the percent basal cover of the two areas had become more nearly alike but there was still a significant difference in forage production, with a yield of only 632 pounds on the heavy litter area and 1693 pounds on the light litter area. Differences in yield between this habitat and the other short grass habitat discussed under fall and spring burning are due to some extent to differences in soil productivity.

Table II.—Average percent cover and yield in pounds per acre air-dry forage showing the effects of burning on the various habitats at different times and under different conditions.

	1945				1946			
		Yield				Yield		
Habitat	Percent Cover	Short grass	Mid grass	Forbs	Percent Cover	Short grass	Mid grass	Forbs
Short grass fall burned	62.2	1918.1		451.6	73.0	733.2		89.7
Short grass spring burned	19.6	634.8		1210.3	44.3	618.0		60.5
Short grass light litter	95.0	2709.5		130.0	83.5	1693.5		71.7
Short grass heavy litter	44.0	1079.9		1058.4	61.9	631.6		116.0
Little bluestem unburned	21.7		3456.8	367.6				
Little bluestem burned	20.6		1076.2	532.7				
Natural revegetation unburned: *Buffalo grass	98.4	4123.0	39.2	198.5	91.4	1322.6		286.2
Natural revegetation unburned: *Sand dropseed	18.5		1368.9	710.2	30.2		1444.5	1630.2
Natural revegetation spring burned: Buffalo grass	40.9	992.4	11.1	1275.4	90.1	1221.1	13.3	253.6
Natural revegetation spring burned: Sand dropseed	2.9	11.9	134.2	1842.9	26.6	254.2	757.7	840.2

*Species making up largest part of the vegetation.

Little Bluestem Habitat

Observations were made in this habitat as to the comparative effects of spring and fall burning but actual records were made only

Fig. 2 (upper). Quadrat in the spring burned short grass habitat showing dead crowns. Ragweed have been removed. June 28, 1945.

Fig. 3. General view of the highland in the College Pasture. Where debris was heavy much of the grass was killed and ragweeds are abundant. June 28, 1945.

Fig. 4. Close-up of a quadrat in the natural revegetation habitat showing the prolific growth of ragweeds after burning. June 3, 1945.

in comparing a spring burned with an unburned area. In the unburned area 3824 pounds per acre of air-dry forage were produced in 1945 while the burned area produced only 1609 pounds (Table II). Forbs made up about one-third of the production in the latter. The low percent basal cover in the unburned area was due to the fact that it had not been grazed for some time and was covered with an abundance of litter. This is a condition which ordinarily causes reduction in cover but may not greatly change the yield.

Little bluestem suffered the heaviest loss with an average kill-back of 35 percent while some plants lost fully 75 percent (Table I). Side-oats grama lost an average of 9 percent with an extreme of 50 percent. Big bluestem had about the same average loss as side-oats grama but the extreme was only 25 percent. Other losses of grasses in this habitat were as follows: hairy grama (*Bouteloua hirsuta*) 40 percent; hairy sporobolus (*Sporobolus pilosus*) 50 percent; and blue grama 55 percent.

Natural Revegetation Habitat

The fire left many open spaces in the buffalo grass islands reducing the cover from almost 100 percent to only 41 percent (Table II). This grass renewed growth rapidly, however, and soon

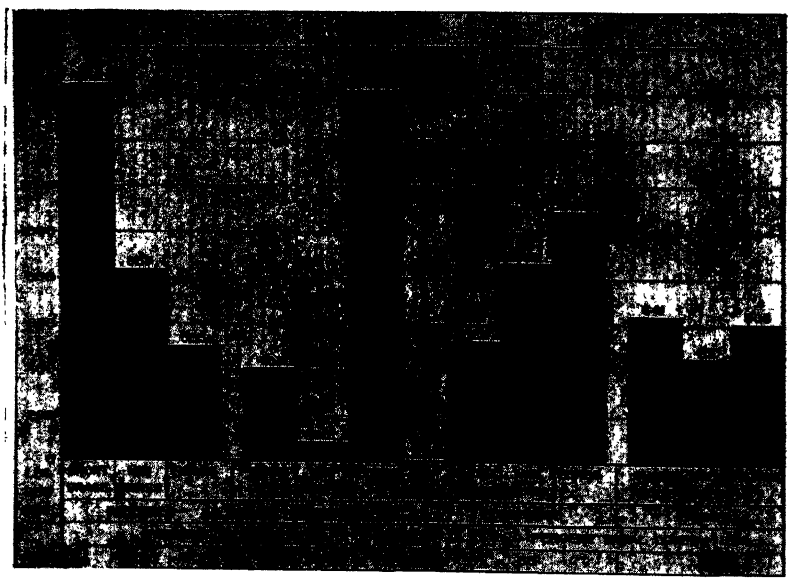


Fig. 1. Percent basal cover and production in pounds per acre in the burned and unburned natural revegetation area in 1945 and 1946.

started sending runners into the open spaces. By the fall of 1946, the cover was back to normal demonstrating the remarkable recuperative power of buffalo grass. Sand dropseed was also badly damaged with many of the older clumps being completely killed. The younger plants were better able to withstand the fire and did not suffer so much damage.

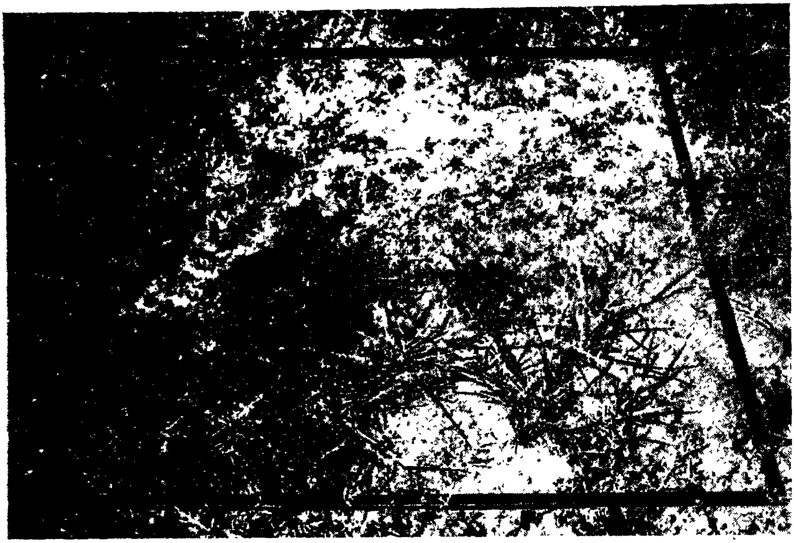
Yield of grasses for 1945 in this habitat was reduced from 2486 pounds per acre in the unburned area to 489 pounds where burned. Forbs, on the other hand, yielded 505 and 1616 pounds per acre, respectively, on the two areas (Fig. 1). These forbs were mostly perennial ragweeds. The burned area had an average of 219 ragweeds per square meter, while only 68 per square meter occurred on the unburned area. Figures 4 and 5 show a quadrat on June 30, 1945, before and after the ragweeds were removed.

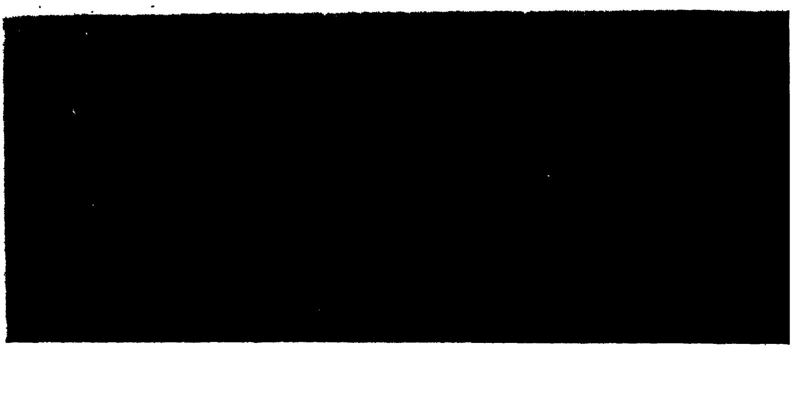
In 1946 the buffalo grass islands increased in both yield and cover where burning occurred while there was a decline in the unburned area due to a shortage of rainfall during the growing season. Total seasonal yield of grasses in 1946 was almost 300 pounds per acre less than normal where burning had occurred two seasons previous. A good many annual weeds invaded the open spaces where sand dropseed was the dominant species but there was little if any distinction as to whether or not burning had occurred.

DISCUSSION AND SUMMARY

The detrimental effect of pasture burning either accidentally or otherwise cannot be over-emphasized. This is especially true when burning is done under certain conditions, some of which have been described. Measurements of losses have been made chiefly on the basis of forage production and percent basal cover, but observations showed that there were other losses not measured in this study. Soil losses through increased erosion, loss of protective soil mulch, and loss of organic matter should be taken into account as well. Recognition of these facts makes it imperative that steps be taken to prevent prairie fires.

In the fall of 1944 and spring of 1945 a mixed prairie consisting of 748 acres was accidentally burned off. This total acreage has been subdivided into various habitats as shown in Table III. Potential production for this pasture had it not been burned was 2,198,322 pounds of air-dry forage as determined from clippings from unburned areas. Actual yield was 959,433 pounds with a loss of 1,238,889 pounds forage during the one season of 1945. Allowing a conservative figure of 60 percent utilization and 25 pounds forage to





produce 1 pound of beef, there was a loss of 29,733 pounds of beef. This loss includes only production during 1945 and not old vegetative matter which was burned and part of which might also have been turned into beef.

Table III.—Comparative total yields in pounds of air-dry forage in the different habitats of the college pasture for 1945.

Habitat	Condition	Acres	Yield Per Acre	Total Yield in Habitat	Est. Lbs. Beef from Forage
Short grass	Unburned	322	2704	870,688	
	Fall burned	128	1918	245,504	
	Spring burned	194	635	123,190	
Little bluestem	Unburned	270	2124	573,480	
	Fall burned	135	1400*	189,000	
	Spring burned	135	1076	145,395	
Lowland wheatgrass	Unburned	46	10429	479,734	
	Spring burned	46	3209	147,614	
Lowland shortgrass	Unburned	30	2518	75,540	
	Spring burned	30	1961	58,830	
Natural Revegetation	Unburned	80	2486	198,880	
	Fall burned	70	643*	45,010	
	Spring burned	10	489	4,890	
Total	Yield unburned	748		2,198,322	52,759
	Yield burned	748		959,433	23,026
	Loss of forage by burning			1,238,889	29,733

*Estimated

Spring burning, under the conditions of these two fires, proved to be more harmful than fall burning. Basal cover was reduced to 62 percent in the short grass habitat on the fall burned area and to 20 percent on the area burned in the spring. Yield of air-dry grass was 1918 and 635 pounds per acre, respectively, from the two areas at the end of the first year of growth. It was obvious early in the spring of 1945 that spring burning had been especially destructive in areas where grazing had previously been light and the accumulation of litter was consequently heavy. On the areas covered by light litter, basal cover was still 95 percent after the fire and yield for 1945 was over 2700 pounds per acre. On the area covered with heavy litter, cover was reduced to 44 percent and yield to 1080 pounds. Injury to the short grasses was also caused by the increased growth of ragweed, a perennial noxious weed. This plant increased to a

Fig. 5 (upper). Same view as Fig. 4 with the ragweeds removed. A few plants of sand dropseed make up the remainder of the vegetation.

Fig. 6. General view of the College Pasture taken September 20, 1943. Broomweed (Gutierrezia sarothrae) has a rank growth and appears to be well established.

Fig. 7. Same view as Fig. 6 but taken on October 2, 1945, after the fire had killed off most of the broomweed.

certain extent in both fall and spring burned areas, but much more so after spring burning. Counts made in June, 1945, showed an average of 182 ragweeds per square meter in the short grass spring burned area as compared to 72 where fall burning had occurred.

In the little bluestem habitat, there was considerable killing of the various species as a result of the fire with little bluestem losing 35 percent of its previous cover. The slight difference in basal cover between the burned and unburned areas was due to the presence of an abundance of debris on the unburned area. This is a condition conducive to a low basal cover. The unburned area produced 3824 pounds of air-dry forage per acre in 1945, while only 1609 pounds were produced on the burned area.

The fire did considerable damage in the natural revegetation habitat, reducing the cover by 60 percent in the buffalo islands and completely destroying many of the older sand dropseed plants. Yields were likewise reduced by burning. Greatest numbers of ragweeds were found in this habitat where there was an average of 219 plants per square meter. One quadrat from which records were made contained 514 ragweed plants. By using the available moisture and shading the dominant grasses this rhizomatous forb severely retarded recovery.

Most damage was done to the individual species which maintain life, though in a dormant condition, in above ground stems or crowns. This may be represented by broomweed (*Gutierrezia sarothrae*), a perennial forb with a woody caudex which maintains life above the soil, and blue grama which remains alive in the crown slightly above the surface of the soil (Figs. 6, 7). Both these species were badly damaged by the fire while goldenrod (*Solidago mollis*) and buffalo grass, which maintain life just below or at the surface of the soil, did not suffer so greatly. Also due to the presence of stolons as a means of vegetative growth, buffalo grass is much better adapted to recovering lost ground.

By the fall of 1946, when this study was closed, complete recovery had still not been attained. Most rapid recovery had been in the natural revegetation habitat where the buffalo grass islands had almost completely restored their normal cover and production. However, in the fall and spring burned areas in the short grass habitat, there was an increase in percent cover but a decline in amount of forage produced as compared to 1945. In all habitats, there was still ground to be regained and vigor to be recovered.

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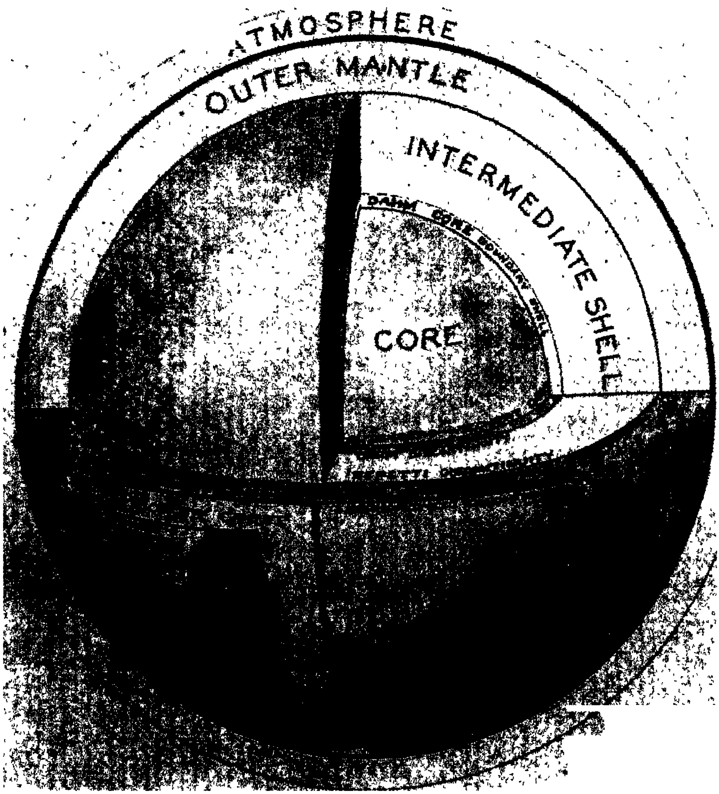

Model of the Interior of the Earth.

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THE STRUCTURE OF THE INTERIOR OF THE EARTH

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Members who were present at the annual meeting of the Academy in Pittsburg on April 30 had the privilege of listening to an excellent and comprehensive lecture on "Our Present Knowledge of the Structure of the Interior of the Earth," the principal public address at the eightieth annual meeting. It is with pleasure that we here present to a larger audience this authoritative review by one of our leading geophysicists. For further information concerning the author, see page 162.—The Editor.

The inside of the earth is of interest to mankind not only as a matter of curiosity, the challenge of the unknown, nor merely because the earth is our habitat, the milieu in which our lives are cast, the storehouse on whose riches our lives depend, but because its contents and structure determine the character and distribution of those all pervading forces which affect every moment of our daily lives and whose strength and variations are of so great importance in the discovery and utilization of hidden stores.

The nature of the earth's interior has fascinated mankind through the ages. Natural philosophers have theorized on it. Geologists have extrapolated surface observations to form conflicting theories concerning it. But it is only in the course of the last one hundred years that reliable scientific knowledge has gradually accumulated until now we have a provisional picture of the interior of the earth which permits certain rather definite conclusions concerning its structure.

Geological prospecting methods and ever-broadening geological surveys together with palaeontological and geochemical investigations have given us a very considerable body of knowledge concerning the uppermost layers of the earth's crust. The study of near earthquakes, both natural and artificial, has permitted the extension of this knowledge in many places to the base of the earth's crust. We still speak of the earth's crust, though the word now has a modified meaning. Early geologists were influenced by the popular con-

ception of the earth as a molten ball with a thin crust perforated here and there by volcanoes. This conception fitted well into the picture of an earth cooling down from a white hot gaseous mass in accordance with the Kant-Laplace and other nebular hypotheses on the origin of the solar system. Modern geologists after a century

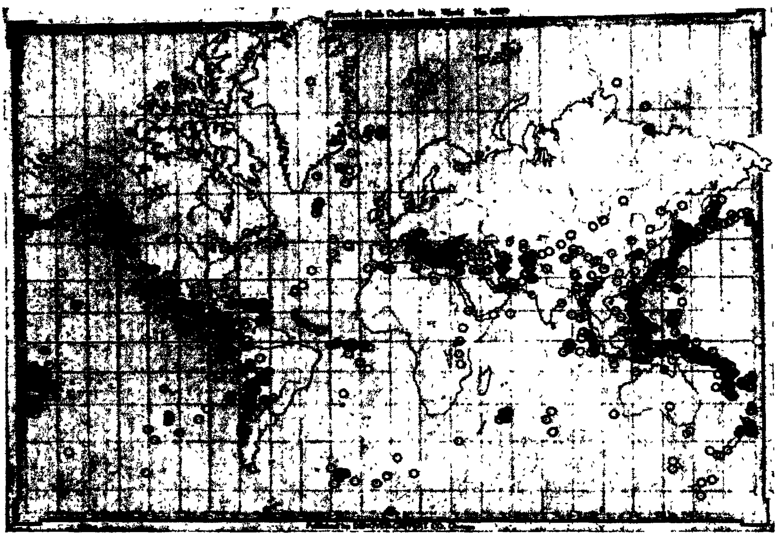

Figure 1. Distribution of the large earthquakes which occurred between 1917 and 1930 showing a heavy concentration in two belts, one around the rim of the Pacific Ocean and the other across Eurasia. Both of these are zones of active or recent mountain building. A less active belt is seen to follow the mid-Atlantic ridge.

of thorough search have failed to find any vestige of such an original crust; and two volcanoes as close together as Kilauea and Mauna Loa do not have a common lava reservoir. What we call the crust is a rigid outer shell separated from a solid interior by a relatively sudden change in properties which is known to seismologists as the Mohorovicic discontinuity(1)*. It is in this so-called crust with its various layers which differ from place to place in character and in thickness that most of the known earthquakes occur(2). The total thickness of the crust also varies between the limits of five and forty miles. The uppermost layer of igneous rock beneath the continents is often called the granitic layer. It is also called the continental layer because it seems to be absent or very thin under the great ocean basins(3) and many of the fringing islands, such as Japan(4) and New Zealand(5). The lower part of the crust seems to be more

*Superior numbers in parentheses refer to references at the end of the paper.

basic and one or other of the intermediate layers under the oceans and beneath the continental layer is often identified as basaltic[6]. The data on which these extremely tentative identifications rest are derived almost entirely from studies of elastic waves, generated by earthquakes and explosions and observed by means of seismographs. In general a disturbance of the elastic equilibrium by over-strain and resultant faulting generates two types of elastic waves which are designated mathematically as divergence waves and curl waves or more simply and less accurately as longitudinal and transverse waves. These two types of waves are generated by the same movement at

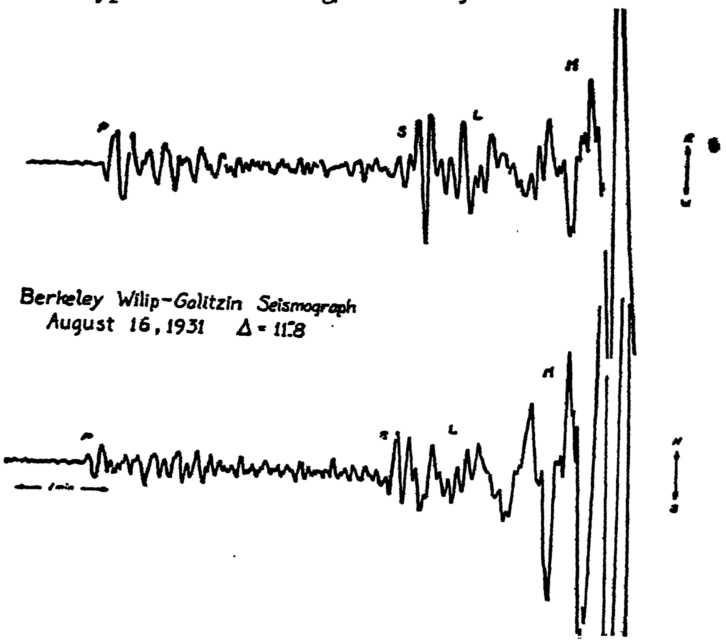

Figure 2. Divergence waves (P) and curl waves (S) followed by surface waves (L, M).

the origin but the divergence waves travel faster than the curl waves[7]. In a homogeneous and isotropic elastic body the square of the velocity is given by the ratio of the elasticity to the density of the medium. The curl waves involve only one kind of elasticity, the rigidity, while the divergence waves involve both volume elasticity and rigidity. By means of a large number of precise observations of the time of travel of both of these types of waves these ratios can be determined with considerable accuracy in the earth; but it is not possible by means of earthquake waves to measure either the elasticity alone or the density alone[8].

As we cross the boundary from the earth's crust into the under-

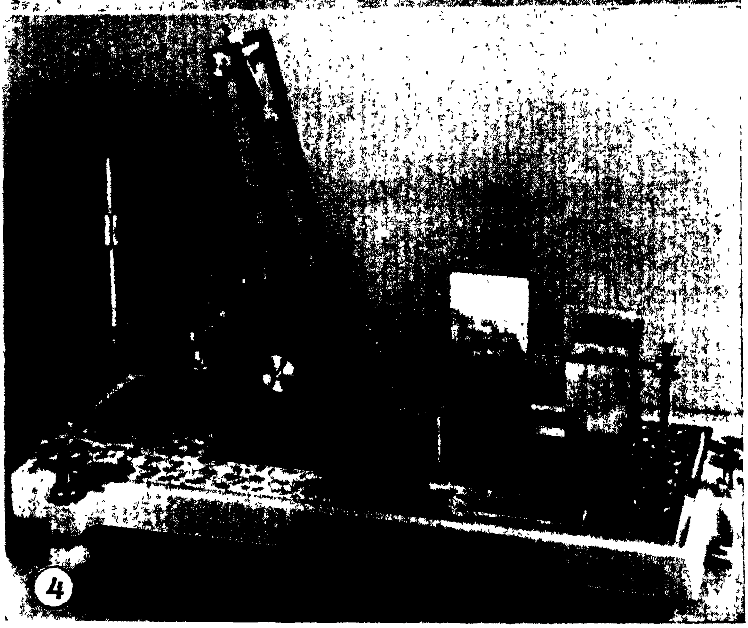

Figure 3. The Sprengnether horizontal component long period seismograph. Nearly all seismographs utilize the principle of the pendulum to secure loose coupling and thus to detect relative motion between the shaking earth and the pendulum bob. In this case the bob is a coil of thousands of turns of fine copper wire. A pair of horseshoe magnets is rigidly attached to the base of the instrument and fits over the coil above and below so that the

lying material, we do not leave earthquakes behind. Those disturbances which have their origin above the Mohorovicic discontinuity are classed as normal earthquakes; those which have their origin below the discontinuity are classed as deep[9]. How can we distinguish between them? The distribution of surface intensity around a shallow earthquake source is regular. It is highest near the center and gradually decreases in all directions until the earthquake is no longer felt. This might be called a normal distribution of intensity. A deep earthquake spreads its energy much more uniformly so that differences of intensity will depend much more on the geological conditions than on distance from the source, with the result that an earthquake may be felt distinctly in widely separated areas, whereas it is imperceptible in the intermediate regions. This is an abnormal distribution of the intensity [10]. However, from the standpoint of the seismologist, the instrumental criteria for distinguishing an earthquake as deep are much more decisive. When the origin of the earthquake is deep, there will be two paths by which the earthquake waves can reach a distant station,—the one direct from the source, the other by reflection from the surface of the earth near the origin.

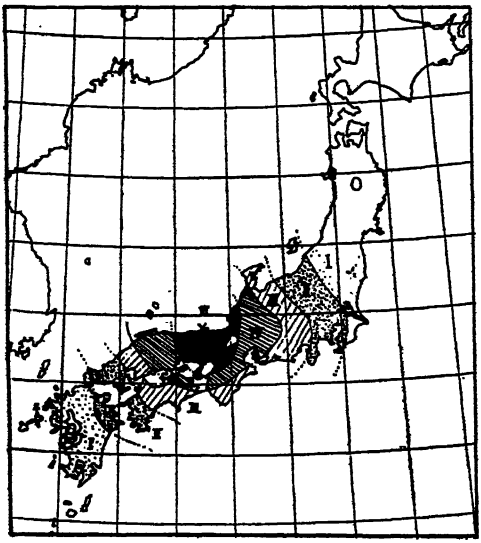

Figure 5. Normal intensity distribution in the North Tazima earthquake in Japan, May 23, 1925. The cross indicates the epicenter on the north shore of the main island and the Roman numerals indicate relative intensities according to Wadati's scale decreasing outwardly in the successive shaded zones.

coil of wire swings freely in the gap between the pairs of magnetic poles, thus generating an electric current like a dynamo. This current is led through the coil of a sensitive galvanometer. The galvanometer coil is thus caused to execute highly magnified swings in step with the earth. Its vibrations are recorded by reflecting a beam of light from a mirror on the galvanometer coil to photographic paper on a revolving drum. This seismograph records horizontal motion in one direction only and responds best to the long waves in distant earthquakes.

Figure 4. The Sprengnether vertical component, short period seismograph. The pendulum with its coil is suspended on an adjustable spring. It responds only to up and down motion of the ground and is very useful to detect the very first onset of any earthquake and the short waves of near earthquakes.

The deeper the earthquake, the greater will be the interval between the arrival of these two impulses or wave trains. It is by the length of this interval between the arrival of divergence waves by the two paths and also between the arrivals of the curl waves by the two similar paths that seismologists measure the depth of the earthquake[11]. The deepest earthquake so far recorded was about seven hundred kilometers or about four hundred and thirty-five miles below the surface of the earth. One of the striking features of these deep earthquakes is the large percentage of elastic shear energy that is released. Many of these earthquakes are of great intensity as measured by their total energy; and a great part of this must have been stored as potential energy of shear strain. It would appear from all available evidence that the mechanism of release is the same in a deep earthquake as it is in a shallow earthquake. The material at depths of hundreds of miles must, therefore, have sufficient strength to allow this type of energy to be stored in large quantities and to permit the shear strain to increase continually until it is suddenly released by failure and faulting in a violent earthquake.

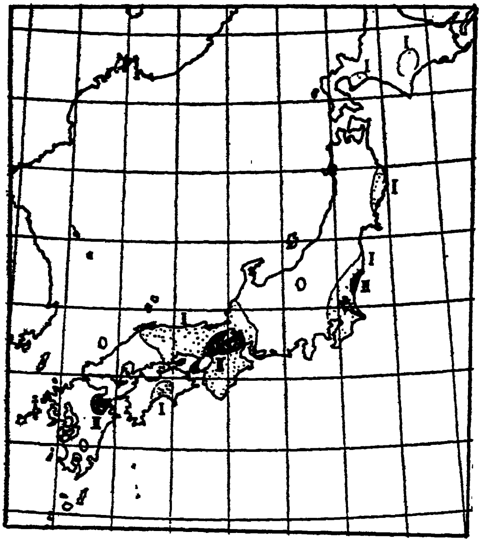

Figure 6. Abnormal intensity distribution in Japan as a result of the deep earthquake of March 29, 1928, whose epicenter was at the point indicated in the Pacific Ocean south of the main island. The Roman numerals indicate intensities according to Wadati's scale.

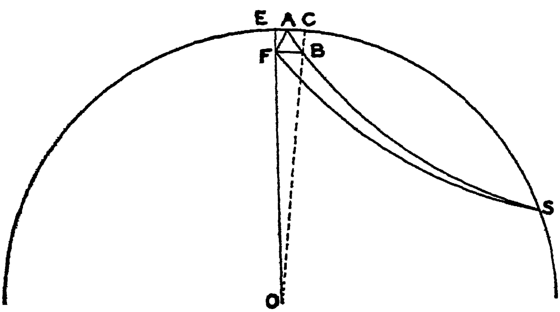

Figure 7. Two paths FS and FAS by which earthquake from a deep focus F may travel to a seismograph station S. The focal depth is FE or BC.

There are many paths by which both divergence and curl waves can traverse the earth and if we plot graphs of arrival time against

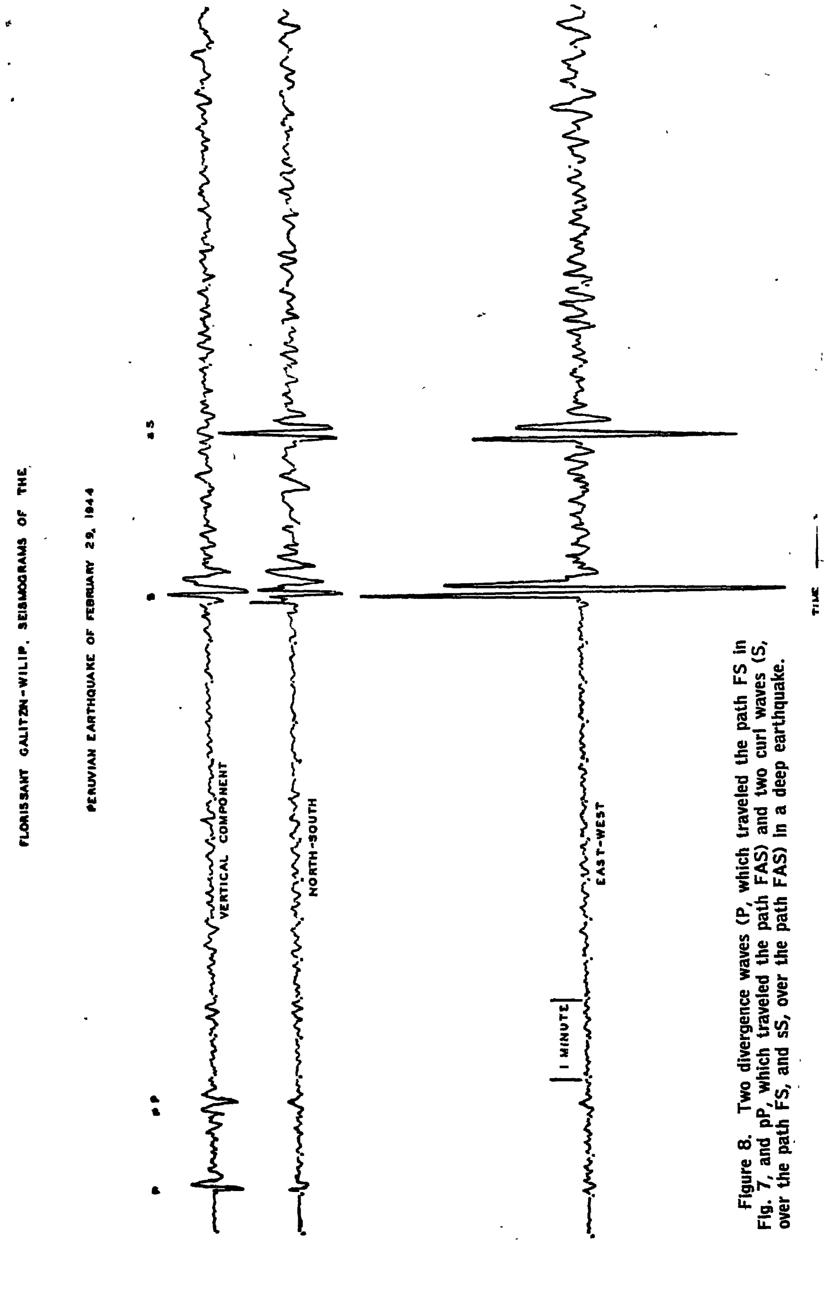

Figure 8. Two divergence waves (P, which traveled the path FS in Fig. 7, and pP, which traveled the path FAS) and two curl waves (S, over the path FS, and sS, over the path FAS) in a deep earthquake.

distance for all these paths, we obtain a very complicated diagram[12].

However, if we concentrate our attention on the first waves to arrive, we can measure with fair precision the apparent velocity of emergence along the surface of the earth up to an arcual distance of a little over 102° or 7140 miles from the origin. The graph of apparent velocity will be concave towards the distance axis up to

Figure 9. Reverend George J. Brunner, S. J., Professor of Geophysics in the Saint Louis University Institute of Technology, using the Brunner Depth-Time-Distance Chart invented by him and published by John Wiley and Sons, New York.

102°, but from there on toward greater distances, it will be very difficult to follow, not only because of a very rapid drop in the energy of the waves, but also, because of scattering of the observations. Experienced seismologists do not agree further in the interpretation of these data than that they form a linear band of points on the diagram. Beyond 102° we seem to enter a shadow zone or a ring of low intensity, and as we proceed further the shadow deepens until we reach a distance of about 140° to 145°. There a new wave of the same type arrives with a sudden burst of energy but one which

takes longer to traverse the earth. This wave energy forms as it were a bright spot filling the inside of the shadow ring and extending all the way to the antipodes.

It is possible mathematically to determine the depth to which successive rays penetrate and the speed at their deepest point as long as there is no sudden break or discontinuity in the curve and as long as it is concave to the distance axis. If we carry out such

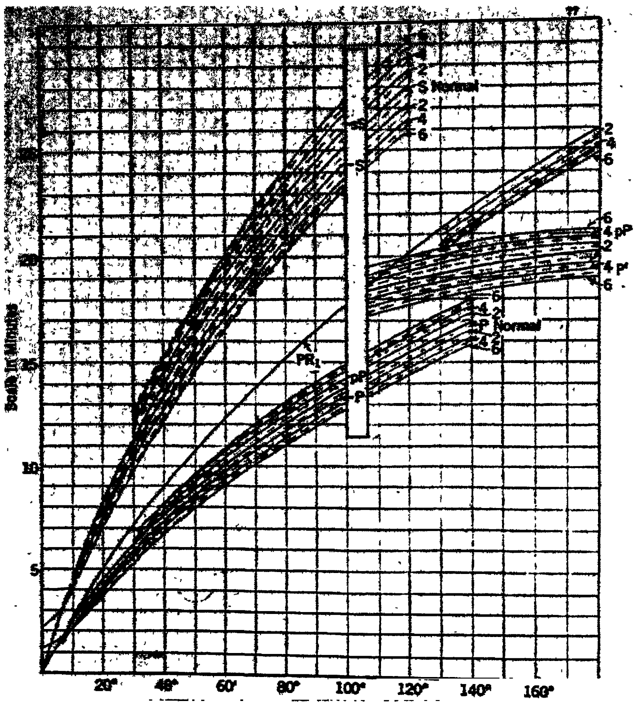

Figure 10. Use of the Brunner chart.

calculations, we can find the depth of penetration and the wave velocity as a function of depth and hence also the depth to which the ray which emerges at 102° has penetrated the earth. Secondly we can use the technique of the seismic prospector on a larger scale and observe the strong echoes which are reflected from a boundary surface down below. If we do so, we shall find that the depth from which the strong echoes come is greater than the depth to which the last available ray, that which emerges at 102°, has penetrated. Therefore there seems to be some type of transition shell between these two depths. Beyond this shell there clearly exists a sudden decrease in wave speed which causes the reflection of elastic waves

with considerable energy[13]. The existence of the shadow zone and bright inner spot and the sudden drop in velocity indicates that there is a body within the earth which acts as a lens focusing the rays into the bright spot surrounded by the shadowzone. This body we call the core. Within the last few years sufficient observations have accumulated to allow a fairly accurate estimate of the size of this core and of the apparent velocity of elastic waves around its periphery. By a process similar to the one used on the outside of the earth, a curve of apparent velocities can be used for the calculation of ray paths and speeds inside the core. The results so far obtained seem to suggest an inner core in which there is an increase in velocity. The existence of such an inner core would explain some of the wave phenomena which have puzzled seismologists for decades[14].

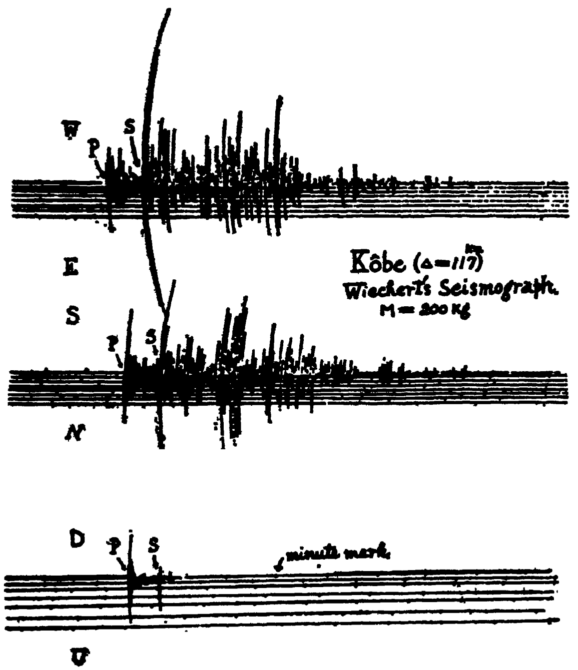

Figure 11. Very large curl or shear (S) waves in the deep Japanese earthquake July 27, 1926, recorded at Kobe 73 miles from the epicenter. The upper record shows east-west movement, the middle record north-south motion and the lower, less magnified record, the up and down motion.

When we compare the calculations made by various mathematicians on the basis of different travel time curves, we should expect to find wide variations. It is surprising, therefore, to see what a small percentage of difference there actually is in the values of speeds down as far as the main core[15]. The characteristics of the outer and inner core are still subject to great uncertainties which must await further research.

We have then as our picture of the earth based on earthquake

data, a layered crust underlain by a shell about six hundred miles thick in which the speed of elastic rays increases rapidly with depth. This may be called the outer mantle. Underneath this mantle there lies an intermediate shell some eleven hundred miles in thickness in which the rate of increase of speed with depth is less rapid but in which the absolute values of speeds of both types of rays are very high, so that we must conclude to the solidity and high rigidity of the entire mantle as far as the outer core. We also are led to the conclusion that there is at the center of the earth a core or nucleus with a little more than one-half the diameter of the earth, or about twice as large as our moon, which strongly reflects elastic waves and which refracts divergence waves. Whether it also transmits curl waves is still an open question[16]. Inside this larger core there would seem to be an inner core about whose constitution very little is known; but which would seem to differ greatly from the outer portion of the main core.

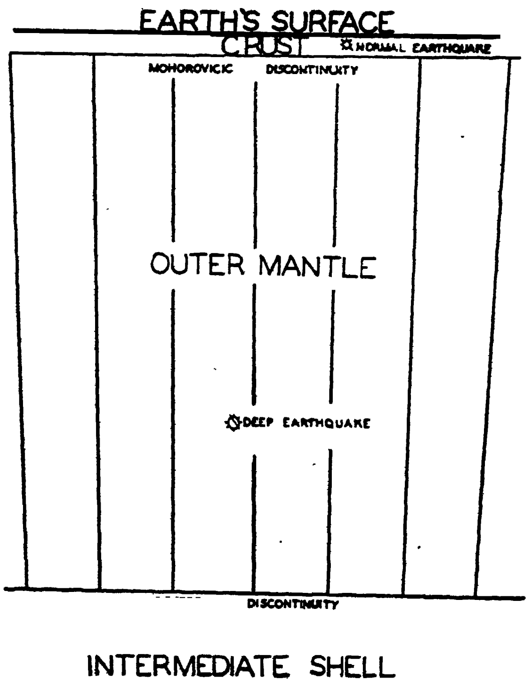

Figure 12. Position of the deepest earthquake so far recorded with reference to the Repetti discontinuity. This sudden change in the rate of increase of wave velocity with depth was described by Reverend W. C. Repetti, S. J., of Saint Louis University and the Manila Observatory in 1928.

As we have said, it is impossible to obtain from seismic data separate measurements of the elasticity and the density. However, there is an indirect method by which we can approximate the distribution of densities within certain limits.

The total mass of the earth is known fairly accurately. The value of the earth's mass as given by Olczak[17] is 597.65 x 10^{25} gm. Also the moment of inertia of the earth using this value of the mass

and the mean radius of the earth is about 81×10^{43} gm.-cm.^{2} Assuming from the best data available the average depth of the earth's crust down to the Mohorovicic discontinuity and an average density for the materials constituting the crust, Bullen[18] has calculated the

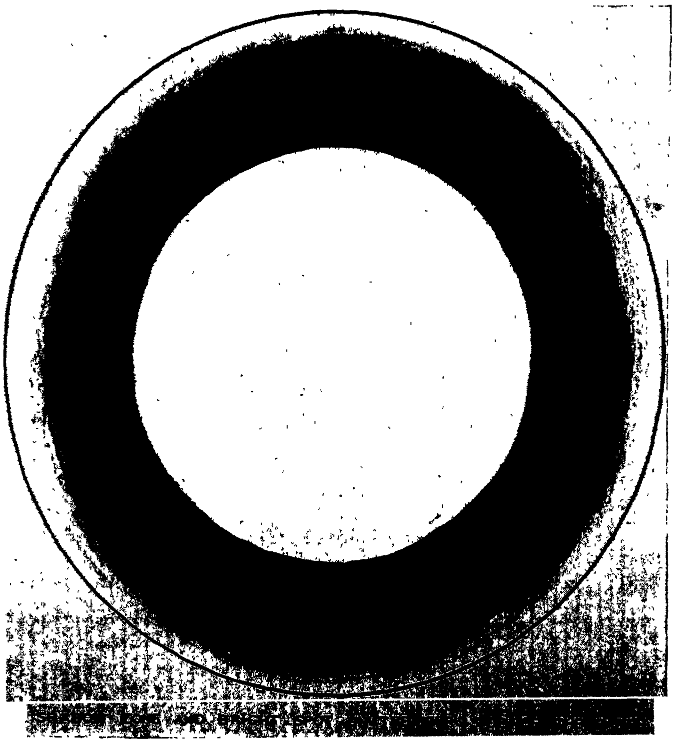

Figure 13. Shadow zone and inner bright spot around the antipodes of an earthquake.

mass and moment of inertia of this average crust. Subtracting each from the mass and the moment of inertia respectively of the whole earth, he found the mass of the earth stripped of its crust to be 593×10^{25} gm. and its moment of inertia to be 79.8×10^{43} gm.-cm.^{2} respectively. Proceeding in this manner from shell to shell down to the core of the earth and balancing possible values within allowable limits, Bullen calculated the density, the attraction of gravity, and the pressures in the interior of the earth as shown in the accompanying graphs plotted from Bullen's published values. Bullen's figures for the core are based on the arbitrary assumption of zero rigidity; but after nearly a decade of calculations he is of the opinion that the values for the pressures inside the earth are fairly reliable; that the

acceleration of gravity is subject to much greater uncertainties and that the values for the density in the core are very uncertain.

In contrast with these rather definite results we know practically nothing for certain regarding the distribution of temperature inside the earth. We have only two sources of information and

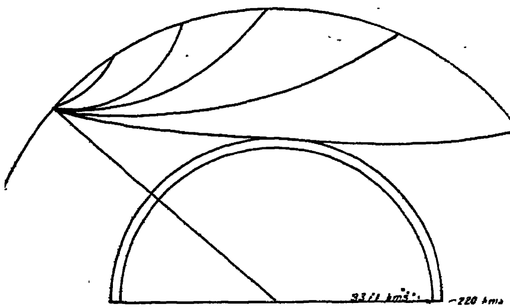

Figure 14. Ray at 102° grazing the Dahm transition shell. This shell was described by Doctor C. G. Dahm at Saint Louis University in 1934.

these are not applicable to more than a very thin portion of the earth's crust. The first source of information is the temperature gradient in wells and mines. The available data have been admirably summarized by Van Orstrand[19]. He concludes that our knowledge of elevations of the isotherms even in continental masses is very in-

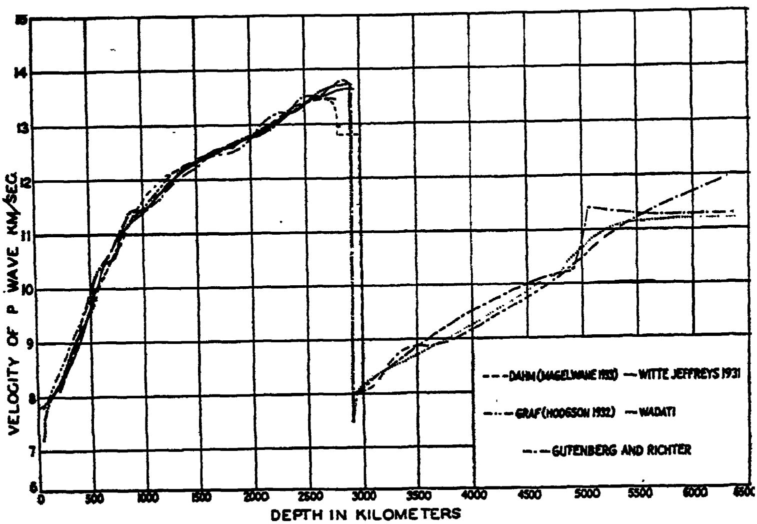

Figure 15. Curves showing the change of velocity of divergence waves with depth according to different calculations.

complete. Observations have been concentrated in oil fields and in mining areas in which the geological conditions are far from normal. In sedimentary strata, the isotherms tend to parallel the upper surface of the basement rocks. He says that only a rough estimate can be made of average gradient; but that a rate of increase of fifty feet per degree Fahrenheit would probably represent a reasonable average over a considerable portion of the sedimentary areas of the globe. Considering the variability of the gradient in the areas in

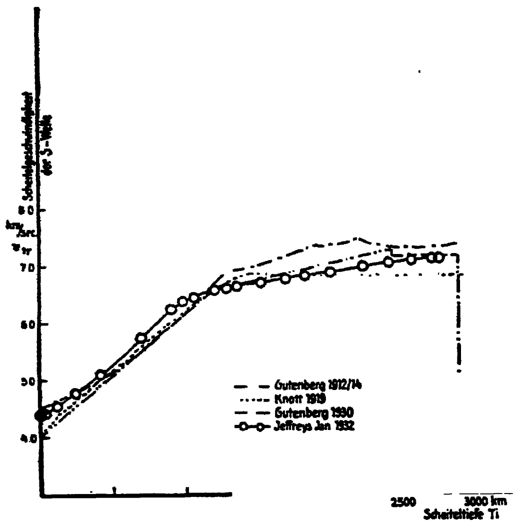

Figure 16. Change of velocity of curl waves with depth. After Witte.

which it has been measured and the slight depth to which measurements have been carried, it would be very hazardous to extrapolate the gradient to any great depth. The second source of information is the approximate distribution of radioactive minerals in the surface rocks of the continents and the rate at which heat is generated by radioactive processes. If the distribution of radioactive minerals were to continue into the earth's core in the same relative concentration as found in the granites and pegmatites of the continental areas or even in the basalts of the larger areas, an impossibly large quantity of heat would have been generated through the ages; so that we are forced to conclude that there must be a decided limitation to their distribution in depth. It is true that the basalts and other basic rocks are found to contain less radioactive material in proportion than the granites, but this observation is balanced to a certain degree

by the fact that considerable deposits of radioactive minerals such as pitch-blends are found in mineral veins[20] which in general would seem to have been due to geothermal processes. This suggests the presence of radioactive substances at depth. There, then, are several

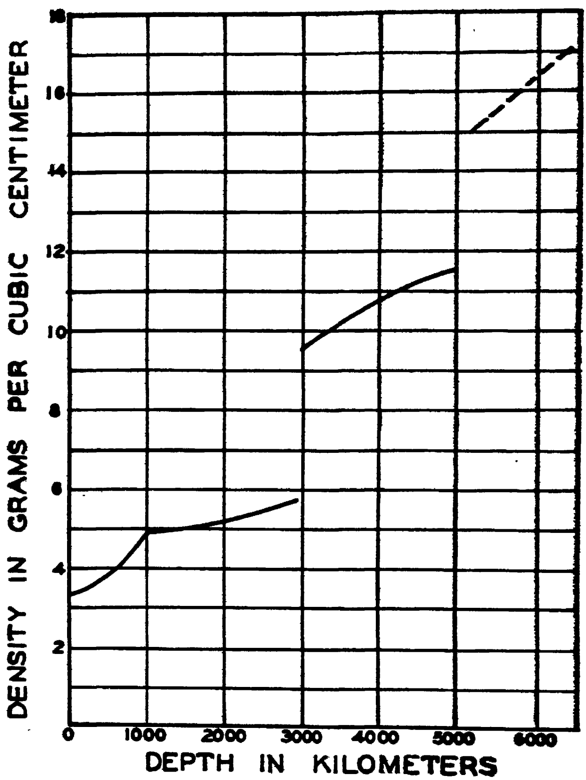

Figure 17. Change of density with depth according to Bullen assuming no rigidity in the core.

possible sources for the earth's heat; first, there is solar radiation; but observations on the annual wave seem to indicate that solar heat does not penetrate beyond a few tens of feet. Secondly, there is radioactivity which certainly furnishes much heat to the outer portions of the earth's crust and may furnish heat at a rate sufficient to account entirely for the loss by radiation from the earth's surface. A third source of heat is that due to exothermal reactions which take place in magmatic bodies and in volcanoes. Fourthly, there are frictional forces which are brought into play by earth tides, diastrophism, folding, faulting, and other similar phenomena. These

sources of heat are on the observation side of the ledger. On the side of hypothesis there is a possible residual heat remaining over from an original molten or even gaseous state. Related to this hypothetical source is heat that might be generated by compression under a cooling crust covering a hot interior or by compaction of

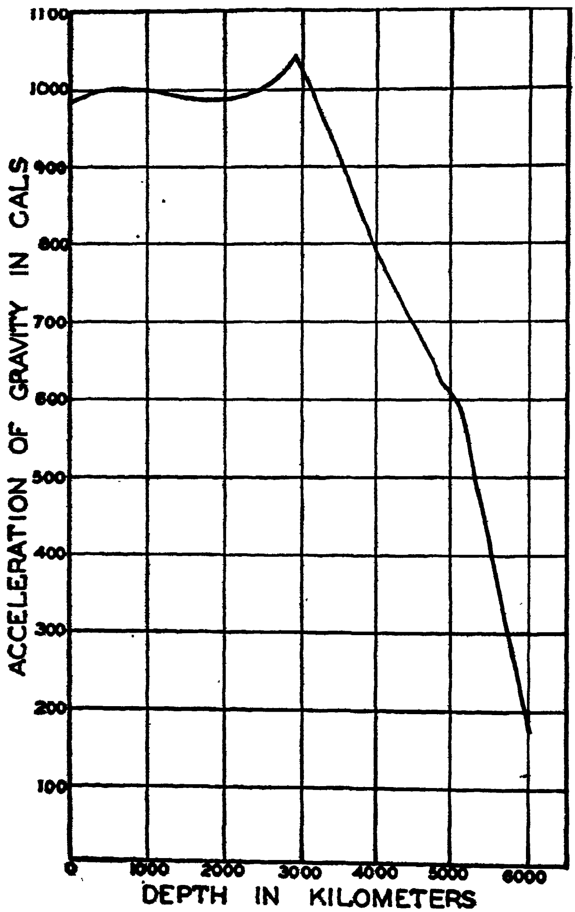

Figure 18. Change of gravity with depth according to Bullen.

accretional materials. All in all then our knowledge of the heat budget of the earth is very limited indeed.

Without a knowledge of temperature and with a certainty of the enormous pressures mounting to more than three and one-half million atmospheres at the center of the earth, is it possible even to

speculate with any reasonable degree of plausibility concerning the physical or chemical state of matter in the core which must be so vastly different from anything we know under laboratory conditions? We are forced to conclude that the discriminatory value of our knowledge of the earth's interior is not great when applied to alternative hypotheses as to the origin of the earth, whether by disruption of a parent star in hot gaseous form or under cold plane-

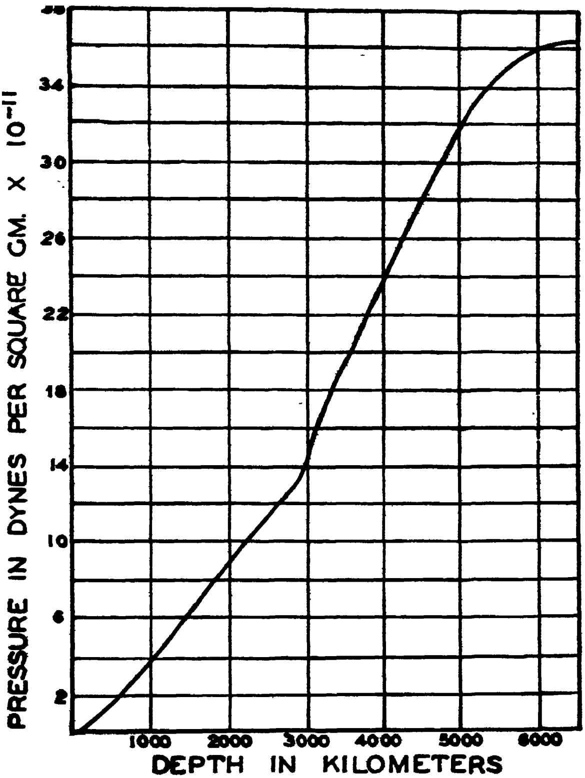

Figure 19. Change of pressure with depth according to Bullen.

tesimal conditions of reconcentration, or whether by capture from a dispersed state. The only limitations that seem to bear on the problem are, first, the age of rocks as determined at least in a qualitative way by the accumulated radioactive products, such as the helium content, the halos, and the residual lead, and secondly, the present rigidity, strength, and layering as indicated by seismic evidence.

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The Editor's Page

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ROBERT TAFT, *Editor*

College commencements this year will be delayed commencements for many students. "I'm twenty-six" said a senior who stopped in at the editor's office not long ago, "and I'm just starting on my profession. I should be twenty-two. Three and a half years in the South Pacific didn't give me many credits in chemical engineering. I wouldn't kick, though, if I could be sure I wasn't going to be called back into service after a year or so. If you read the newspapers it seems as if there is no hope for eventual quiet. In fact, I've gotten so discouraged when reading the newspapers that I seldom look at anything any more but the sport page and the funnies."

Doubtless most of us will sympathize deeply with the young man and, if our feelings had complete control of the situation, we would likewise read nothing but the sport page and the funnies. In fact, one gets the unpleasant sensation at times, that national leaders of all parties read nothing but the funnies and the rest of us read little or nothing at all.

Certainly a major cause of the despair and the confusion of the present day is the lack of exact information. To those of us accustomed to build our theories, principles, and action upon fact —with careful scrutiny of "the facts"—this situation, the lack of exact information, is the most disturbing. What are the facts, that is, is there any way of ascertaining the truth with certainty—or as much certainty as exists in this uncertain world? Can the facts, if established, be presented without prejudice or strong bias? Once the facts are established and presented fairly, can we expect a reasonable solution to our many problems?

If one can judge from the great scientific achievements of past and recent years, the answer is "yes" to all the questions raised above. Facts *can* be established, principles deduced and action taken for the solution of problems. Our failure, therefore, must come in the lack of recognition of procedure and of the will-to-do on the part of our leaders; a failure, therefore, eventually to be charged to us all.

* * *

Dean James B. Macelwane, S. J., whose article is featured in the present issue of the *Transactions,* is of Irish descent but is a

native of Ohio, having been born near Port Clinton, Ohio, some 65 years ago. Father Macelwane was graduated from St. Louis University in 1910, and after teaching experience in Ohio high

DEAN J. B. MACELWANE, S.J.

schools and at St. Louis University in the field of physics, completed his formal education at the University of California where he received the doctorate in 1923. From 1923 to 1925 he was geologist in charge of seismographic stations in California but in 1925 he returned to St. Louis University as professor of geophysics and director of the department. From 1927 until 1933 he was dean of the graduate school at St. Louis and at present is dean of the Institute of Technology, St. Louis University.

Dr. Macelwane is a member of a number of scientific organizations and has been honored for his professional labors in many of them. From 1927 until 1929 he was president of the Seismological Society; from 1938 to 1941, he was president of the seismological section of Geophvsical Union, and he has served as president of our two sister organizations, the Missouri Academy of Sciences (1937) and the St. Louis Academy of Sciences (1937-39). Since 1944 he has been a member of the National Academy of Sciences. Dr. Macelwane's special fields of investigation, in addition to the topic included in the present review, have centered around the behavior of waves and vibrations, especially as they contribute to our knowledge of seismology in general and to the structures of the earth in particular.

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

A proposal for the establishment of a geography section of the Academy was made at the Pittsburg meeting. The formation of the section is apparently creating considerable interest throughout the state. As there are now a number of geograohers at both Kansas State College and the University of Kansas, as well

as in other colleges of the state, a specialized section for geography should have considerable support. Meetings of the section would provide opportunity for presenting papers in the fields of climate, weather, and economic, regional and political geography. Here is a chance for geographers to speak for themselves; anyone interested is urged to drop a note to Prof. Karl Stacey, department of geology and geography, Kansas State College, Manhattan. Prof. Stacey will try to organize a program for the 1949 meeting of the Academy at Manhattan if sufficient interest is shown.

Another important step in the affairs of the Academy, taken at the business meeting held in Pittsburg, was approval of affiliation of the newly organized Kansas Psychological Association with the Kansas Academy of Science. This new organization has been in the process of development during the past year, and the first meeting as an organization was held in conection with the Academy meeting in Pittsburg. It is designed to serve as the official organization of all psychologists in the state and will eventually be affiliated with the American Psychological Association. Approval for affiliation with the Academy was voted with the provision that the Kansas Psychological Association would assume responsibility for the program for the psychology section of the Academy at each annual meeting. Officers of the new organization as elected at the Pittsburg meeting were: president, Albert C. Voth; president-elect, Joseph W. Nagge; Member-at-Large, board of governors, Roger B. Barker. Other members of the board of governors are: the secretary-treasurer and the representative to the American Psychological Association, both of whom are selected by the board of governors, and a representative from the Kansas Association of Consulting Psychologists.

The annual meeting of the Missouri Valley section of the Society of American Bacteriologists was held at the University of Kansas on March 26 and 27, 1948. Some fifty representatives of laboratories and schools from Kansas, Oklahoma, Nebraska, and Missouri were in attendance.

The Wyandotte County Lake was opened April 1 after more than ten years of preparation and the expenditure of over six million dollars of Federal and county funds. Fishing was scheduled to begin about June first.

Dr. T. F. Andrews, who this year received his doctorate from Ohio State University, has joined the biology staff of Kansas State Teachers College at Emporia. Dr. Andrews began his duties with the opening of summer school.

Persons interested in the conservation of our natural resources may profit from reading the late Gifford Pinchot's *Breaking New Ground,* published late in 1947 by Harcourt, Brace and Co., which sells at retail for $5. The book is in part an autobiography and in part a history of the conservation movement in the United States during its first half-century. Like many another innovator and leader of great

causes, Pinchot was a fanatic. His zeal for conservation, particularly of the forest resources, knew no bounds. This fact should be kept in mind by readers of his book. But his intense idealism was not unmixed with shrewd practicality. These qualities, plus his extraordinary energy and devotion to the public welfare, enabled him to become, and throughout his active life to remain, the leading American conservationist. The book is an interesting, informative and stimulating account of what conservation is and of what its establishment and maintenance require.—F. D. Farrell.

Dr. E. G. Kennedy of the guidance bureau at the University of Kansas has accepted a position as director of guidance at Kansas State Teachers College at Pittsburg. He will begin his new duties at Pittsburg on August 1. Arrangements are also being made for him to spend part of his time doing field guidance work in Kansas for the State Board for Vocational Education.

Among the promotions recently announced at Kansas State college and the University of Kansas the following persons in various scientific fields were included:

UNIVERSITY OF KANSAS

From associate professor to professor: R. M. Dreyer, *geology;* William Young, *anatomy;* P. O. Bell, *mathematics.*

From assistant professor to associate professor: Max Dresden, *physics;* R. C. Mills, *biochemistry;* Fred Kurata, *chemical engineering;* Jacob Kleinberg, *chemistry.*

KANSAS STATE COLLEGE

From assistant professor to associate professor:

J. B. Devries, *chemistry;* Karl Stacey, *geology;* S. T. Parker, *mathematics.*

From instructor to assistant professor:

L. A. Schafter. *botany;* C. A. Darf, *chemistry;* R. A. Beers, *chemistry;* H. L. Mitchell *chemistry;* Otto Temeier, *zoology.*

Plans are being made for an amateur radio station on the campus of the Kansas State Teachers College at Pittsburg. The station will have power of 400 watts and will operate on a narrow band FM frequency. Plans are underway to form an amateur radio club. All technical work is being done by the advanced class in radio communication and the station is to be operated by student members of the radio club. John L. Johnston, instructor in the physical science department, is in charge of the project.

Dr. David Rapaport, director of research at the Menninger Clinic, Topeka, has resigned to accept a research position at the Austen-Riggs Foundation, Stockbridge, Mass. Dr. Rapaport has also served for the past two years as consulting psychologist at the Winter VA Hospital, Topeka.

Dr. M. D. Scheerer, now of the graduate faculty of the New School, New York City, has been appointed professor of psychology at the University of Kansas. Dr. Scheerer received his doctorate at the University of Tamburg, Germany, in 1933 and has since taught at the University of Louisville, Brooklyn College, and

the City College of New York, as well as at the New School.

Eighteen members of the chemistry staff of Kansas State College, Manhattan, were guests of the chemistry department staff at the University of Kansas on May 8th. The day was spent in examination of the laboratories at the University, and in a discussion of research and other problems common to both groups.

Dr. M. W. Mayberry, assistant professor of botany at the University of Kansas, has resigned his position to accept an associate professorship of botany at the Central Washington College of Education, Ellensberg, Washington. Dr. Mayberry has been a member of the botany staff at Kansas since 1937.

Professor O. W. Tollefson of the department of geology and geography, Kansas State College, Manhattan, will be on leave during the school year of 1948-49. Professor Tollefson will continue work on his doctorate at the University of Minnesota during his leave.

Dr. H. E. Schrammel, head of the department of psychology and philosophy, Kansas State Teachers College, Emporia, retires on September 1. Dr. Schrammel has reached the retirement age of 65 for departmental heads set by the Board of Regents but will continue teaching and research.

Dr. Otto Tiemeier of the department of zoology, Kansas State College, Manhattan, is employed this summer as a biologist by the Kansas Forestry, Fish and Game Commission. Dr. Tiemeier is to assist in the development of a program for the introduction of the multiflora rose in the state, as this rose provides excellent cover for wild life.

Mr. Farrell Branson, instructor in botany at Fort Hays Kansas State College, has resigned his position in order to complete work on his doctorate at the University of Nebraska. John L. Launchbaugh, Jr. who received his M.S. degree from the College this June, will succeed Mr. Branson. Mr. Byron Blair has also been added to the botany staff at Fort Hays as instructor.

Dr. F. C. Gates and Dr. D. J. Ameel of Kansas State College, Manhattan, will both be present at the University of Michigan Biological Station, Cheyboygan, Mich., from June 21 until August 14. Dr. Gates will, as he has for some years, teach ecology, and Dr. Ameel will serve as investigator on the embryology of trematodes.

Mr. Jackson J. Austen who has served for the past two years as part-time biology instructor at Baker University, Baldwin, will become a full-time instructor in the psychology department of Baker beginning with the fall term.

Dr. George M. Robertson has resigned his position as professor of zoology at Fort Hays Kansas State College to accept a position in the biology department of Grinnell College, Grinnell, Iowa. Dr. Robertson has been a member of the Fort Hays staff since 1938 and has been head of the zoology department since 1942.

Dr. J. L. Hermanson, for the past several years a member of the staff of Gustavus Adolphus College, St. Peter, Minn., returns to Bethany College, Lindsborg, as professor of chemistry and dean of the college beginning with the fall semester.

Mr. William Schechter, for the past several years a research fellow at the University of Kansas, has accepted an associate professorship in chemistry at Sterling College beginning in September. Mr. Schechter is completing his requirements for the doctorate at the University in the field of inorganic chemistry.

Dr. Jerry W. Carter, Jr., director, on leave of absence from the Wichita Guidance Center, has received an appointment as scientist in the U. S. Public Health Service. His appointment is for work in the operations section of the division of metal hygiene of the U. S. Public Health Service. He is stationed in Washington, D. C. and will serve in an advisory and consulative capacity to state and local communities who are interested in developing community services for the prevention and treatment of mental health problems. Dr. Joseph E. Brewer is now serving as the acting director of the Guidance Center, formerly the Wichita Child Research Laboratory.

W. Mack Barlow, chemist, and J. A. Edinborgh, electrical engineer, have been added to the staff of the University of Wichita Foundation for Industrial Research. Mr. Barlow was graduated from the Universit·· of Kansas in 1938 and Mr. Edinborgh from the University of Oklahoma in 1941.

Mr. Paul Renich becomes professor of chemistry at Kansas Wesleyan University, Salina, with the beginning of the fall semister. Mr. Renich is completing his work for the doctorate at the University of Kansas in the field of physical chemistry.

The remarkable growth of scientific investigation in Kansas since the war is reflected in the extended lists of new members elected to the two state chapters of Sigma Xi, honorary scientific society. The individuals whose interest and ability in research have brought upon themselves this deserved honor during the past school year include:

At Kansas State College:

CHAPTER MEMBERS

Paul L. Brown	William W. O'Donnell
Clarence S. Clay	Sidney T. Parker
Brinton M. Dirks	Fred L. Patterson
Leland S. Hobson	Lowell H. Penny
Seward E. Horner	Helen I. Peterson
Howard E. Jones	Gabe A. Sellers, Sr.
Joseph Lundhold, Jr.	Floyd W. Smith
John D. McNeal	Paul M. Young
Lester L. Newkirk	Ralph A. Young
Sukh D. Nijhawan	

ASSOCIATE MEMBERS

Alven W. Neff	Harold E. Scheld

At the University of Kansas:

CHAPTER MEMBERS

Howard H. Barnett	Jerome Schiffer
S. Chakravorty	Elwood A. Sharpe
Richard Ferm	Thomas R. Smith
Grace M. Heider	August Sveinbjornsson
Samuel G. Kneale	Wilmer M. Tanner
Walter Kollmorgen	Gordon G. Wiseman
Warren K. Moore	
James O. Riley	

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Jerry Brown	John M. Hunt
Arthur O. Chapman	Robert M. Kloepper
M. Ira Dubins	William McBee, Jr.
Robert B. Finley	Duncan J. McGregor
Charles V. Foster	Edwin P. Marks
John W. Harbaugh	Norman G. Miller
Richard M. Hoover	John Naff
Cluff E. Hopla	James Parks
A. L. Hornbaker	Margaret M. Pihlblad
Henry E. Hughes	Wealthy Purrington

Wayne L. Reeve	William D. Thompson
Alexander Roth	Edward L. Todd
Colleen P. Roth	Fred Truxal
Charles F. Smith	Austin B. Williams
Alfred C. Spreng	John L. Yarnell
Ray J. Stanclift, Jr.	Edwin N. York
Roger Stoneburner	Edward Zeller

One of the most extended and ambitious research projects now under way in the state is an exhaustive attack on the problem of tularemia (rabbit fever). An extensive virus laboratory has been completed at the University of Kansas during the past spring and will house much of the work of this investigation. The laboratory building, approximately 25 by 125 feet, was constructed from war surplus materials and has been attractively finished and thoroughly equipped. About two-thirds of the space of this building is used for the work on tularemia, the remainder of the building providing space for an animal laboratory and a classroom. The virus work proper is provided for in one teaching and five research laboratories. Specially designed cubicles for inoculation, isolation rooms for test animals and incubating and sterilizing rooms are also available in the new building.

The project, originally begun over a year ago, is being financed by grants from the United States Navy. Some $25,000 was provided for the first year's work and a second grant of $42,000 will continue the work up to April 1, 1949. Plans are being made, however, to continue the work, if possible, until July 1, 1951.

The plan of investigation includes a three-pronged attack upon the disease under the coordinator of the project, Dr. Cora B. Downs, professor of bacteriology in the University. The major attack is being made in the field of immunity and transmission of the disease itself. In addition, however, the nutrition of the organism giving rise to the disease is being studied by biochemists under the direction of Dr. R. C. Mills, and field work on animal hosts and parasites of the organism is being carried on by the departments of zoology and entomology under the direction of Drs. E. R. Hall and H. B. Hungerford. The project employs at present, in addition to those mentioned above, some 10 research assistants and technicians.

Publications of the State Agricultural Experiment Station, Manhattan, recently announced, include:

Bulletin 331 *Principal Noxious Perennial Weeds of Kansas,* John C. Frazier. The bulletin reports studies on the growth and control of field bindweed, hoary cress, Russian knapweed, dogbane and climbing milkweed.

Technical bulletin 62 *The Effect of Defoliation on the Functions of Red Winter Wheat,* E. C. Miller, G. A. Gries, W. A. Lunsford, and J. C. Frazier.

Technical Bulletin 63 *A Study of Equine Fistulous Withers and Poll Evil,* L. M. Roderick, Alice Kimball, W. M. McLeod, E. R. Frank. This bulletin reports that horses acquire the above infections from infected cattle and may disseminate the infection to healthy cattle.

Technical Bulletin 64 *Improved Dried Whole Egg Products,* R. M. Conrad, Gladys E. Vail, A. L. Olsen, Gwendolyn L. Tinklin, J. W. Greene, and Charles Wagoner. T B 64 reports the devel-

opment of a process for dehydrating eggs free from undesirable odors and flavors and of improved keeping and cooking qualities.

Copies of the above bulletins may be secured by addressing the Experiment Station.

Publications of the State Geological Survey, Lawrence, issued since the March number of the *Transactions* include Bulletin 65 *Geology and Ground Water Resources of Kiowa County,* Bruce F. Latta, 151 pages; 25 cents.

Bulletin 67 *Kansas Clay, Dakota Formation,* Norman Plummer and John F. Romary, 240 pages; 25 cents. Reports tests on the ceramic properties of clays some of which are suitable for the expanding ceramic industry in the state.

Bulletin 69 *Geology and Ground-Water Resources of Seward County, Kansas,* Frank E. Byrne and Thad G. McLaughlin, 140 pages; 25 cents.

Bulletin 71 *Ground-Water Resources of the Kansas City, Kansas Area,* V. C. Fishel, 109 pages, 25 cents.

Bulletin 76, Part 1 *Graphic Representation of Oil-Field Brines in Kansas,* Russell M. Jeffords, 12 pages; 10 cents.

Bulletin 76, Part II *Contamination of Deep Water Wells in Southeastern Kansas,* Charles C. Williams, 16 pages; 10 cents.

Bulletin 76, Part III *The Occurrence of Corals in Late Paleozoic Rocks of Kansas,* Russell M. Jeffords, 24 pages; 10 cents.

Preliminary Cross Section No. 6, Oil and Gas Investigations, *Subsurface Geologic Cross Section from Baca County to Yuma County, Colorado,* John C. Maher, 11 pages and folded map; 25 cents.

Copies of the above bulletins may be secured without charge at the State Geological Survey offices, University of Kansas, or they can be obtained for the mailing charges indicated above by addressing the Survey.

Dr. H. A. Ireland, now director of geologic research for the Standard Oil Company of Texas, has been appointed professor of geology at the University of Kansas beginning with the fall semester. Dr. Ireland, a graduate of the University of Chicago, has taught at the University of Oklahoma and has also had some years' experience with the U. S. Geological Survey and with the U. S. Soil Conservation Service.

Mr. A. G. Fischer, now a member of the staff of the University of Rochester, has also been added to the geology staff at the University as instructor. Mr. Fischer plans to complete the requirements for his doctorate at Columbia University during the summer.

Dr. A. D. Weber, head of the department of animal husbandry, Kansas State College, Manhattan, has been made assistant director of the State Agricultural Experiment Station.

Two Kansas counties, Cloud and Sherman, received 40,000 trees for planting during the past spring. The trees, used for windbreaks and shelter belts, were chiefly planted in Sherman County by specially designed tree-planting machinery. We hope

shortly to publish a report in the *Transactions* on the present status of the extensive tree-planting project begun some fifteen years ago in the state.

Dr. H. H. King, since 1918 head of the chemistry department at Kansas State College, Manhattan, retires, effective July 1, and becomes emeritus professor. Dr. J. S. Hughes, professor of biochemistry since 1918, has been named acting head of the department.

The security and prosperity of the United States depend today, as never before, upon the rapid extension of scientific knowledge. So important, in fact, has this extension become to our country that it may reasonably be said to be a major factor in national survival. - - - - Scientific discovery is equally the basis for our progress against poverty and disease. This, alone, would provide adequate justification for public interest and support. If we are to remain a bulwark of democracy in the world, we must continually strengthen and expand our domestic economy and our foreign trade. A principal means to this end is through the constant advancement of scientific knowledge and the consequent steady improvement of our technology. - - - - The technology in which we excel and which has transformed us in some 80 years from a backward agricultural nation to a world power rests upon progress in the basic sciences. Only through research and more research can we provide the basis for an expanding economy, and continued high levels of employment. — From *Science and the Public Policy*, volume 1, 1947.

Pasture Types of Western Kansas in Relation to the Intensity of Utilization in Past Years*

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Introduction

Short grass pastures on the high plains of Western Kansas vary in their ability to produce forage for livestock consumption. One of the reasons for this difference is a variation in the degree of utilization in past years. Forage production of short grass ranges has been reduced to about one-half after only a few decades of improper grazing; therefore the problem of proper utilization is becoming more important every year (Forest Service, 1936). When the early settlers came to western Kansas they found an almost complete cover of native vegetation and for a number of years only a small portion of the range was put under cultivation. With the coming of the dry land farmer, however, a large percentage of the native prairie was broken. A recent survey shows that in the Great Plains Region there are about 17 million acres of range land as compared to approximately 11 million acres of crop land (Great Plains Committee, 1936). Many operators have been unable to adjust their livestock programs to the range lands that are diminishing in area and yield. Some have reduced their stocking rate so much that it has resulted in their pastures being undergrazed. Many operators, however, have retained too many animal units on their pastures, thereby producing some badly overgrazed grasslands.

The detrimental effects of improper management of the short grass ranges have never been fully understood. Farm operators have observed that some pastures are inferior to others, but they have been unable to correlate these conditions with past treatment. Many have been unable to recognize areas that have been either too lightly or too heavily utilized. This inability is probably due to the enormous changes that take place in the vegetative cover of the pastures during extreme variations in climatic conditions as well as those that result from light or heavy grazing. The effect of drought, dust, and different intensities of grazing upon the yield of short grass pastures was investigated by Albertson and Weaver (1944). Four classes of pastures were studied with reference to the amount of grazing and dusting to which each had been subjected in past years. The basal cover

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and composition of vegetation, the annual and monthly yields of dry forage, and the effect of different intensities of clipping on the yield of grasses were determined for the four classes of pastures during the two years immediately following the drought. Lacey (1942) found that moderate grazing maintained a constant forage yield and short grass cover, except under adverse climatic conditions, when a considerable decrease in short grass yield was noted. No data have been found, however, on the condition of various pasture types following a few years of normal or above-normal precipitation after the drought.

A number of other studies have been made which closely parallel the work described in this paper. They are concerned, however, with areas that would not be expected to produce the same results as the pastures of western Kansas.

Weaver and Hanson (1941) described five stages in the degeneration of native midwestern prairies and pastures of Iowa and Nebraska. According to their response to grazing, plants of the prairie were placed in six groups: (1) prairie grasses that decrease under grazing, (2) forbs* that decrease under grazing, (3) grasses that increase under grazing, (4) forbs that increase under grazing, (5) grasses that invade pastures and (6) weedy forbs that invade pastures.

The short grass ranges of the central Great Plains were classified into excellent, good, fair, and poor pastures by Costello and Turner (1944). These different classes of pastures were described thoroughly for the purpose of making the different conditions easier to recognize. The fluctuation in the annual forage production for the different classes was discussed but no comparison between the pastures was made. Different degrees of mountain meadow range conditions of eastern Washington and eastern Oregon in relation to grazing intensities were determined by Reid and Pickford (1946).

Jones (1934) studied the influence of grazing on the botanical composition and the productivity of pastures in England. The effect of different intensities of grazing upon native vegetation of the northern Great Plains has been studied by Sarvis (1923). This report stressed the effect of intense grazing upon the principal grasses and forbs of this region and the use of plants as indicators of range conditions.

The purpose of this study is to determine the characteristics of five pastures that have been subjected to different intensities of grazing in the past 15 years.

*Forbs—A collective ecological term referring to non-grassy, herbaceous plants.

Method of Study

Five pastures were selected for study. They were selected and classified with reference to the intensity of grazing to which they had been subjected during the past 15 years. General observations upon the amount of old growth present and the appearance of the vegetative cover were also used for distinguishing the types.

The history of the pastures with respect to the grazing program and general appearance for 15 years prior to the beginning of the study was obtained from the farm operator. A short description was also made of the general appearance of the pastures in the spring of 1946.

A detailed study of the differences found in these five pastures was made along the following lines: Basal cover and composition of the vegetation, monthly and seasonal yields, growth of the short grasses in height, growth and number of buffalo grass stolons, and amount of litter and debris present at each location. General correlations between cover, yield and growth of the short grasses were also made. In order to make the data more comprehensible environmental conditions affecting growth were measured during the period of study.

Representative areas in each of the pastures were selected for study and protected from grazing by exclosures for the entire growing season of 1946. Twenty clip quadrats, each a meter square, were laid out inside these experimental areas.

Since the basal cover of vegetation bears a direct relationship to the value of a pasture, all quadrats were charted with a pantograph at the beginning of the season. In charting, only places without cover of native perennial grasses larger than .8 of an inch in diameter were considered bare. The percentage of basal cover for each species in all quadrats was computed by the use of a planimeter. The average of the twenty quadrats at each location was used as the representative cover for the pasture.

The total number of forbs and the number for each species per 100 square feet were determined in all of the pastures. This was accomplished by using two stakes and a chain to draw 10 to 15 circles, each having an area of 100 square feet, at representative locations throughout the pasture. The native forbs were counted and identified in the circles and the average taken as representative of the forb population of the pasture.

Since the value of a pasture lies primarily in its ability to produce forage for livestock consumption, the monthly and seasonal yields of each pasture were determined. Ten quadrats in each of the

exclosures were clipped once a month from April to September, inclusive, and all vegetation was air dried and weighed. The amount of short grass in pounds per acre for each month of the growing season was determined in all pastures. The sum of the monthly yields was computed as the seasonal yield for the clipped series. The other ten quadrats in each pasture were set aside to be harvested only at the end of the growing season. They were clipped at the end of July, however, to avoid loss of dormant vegetation due to the midsummer drought. The final clipping was made the last of September and the average weight of the air dried forage was computed as the seasonal yield for the unclipped series in each of the pastures.

The growth in height of the two major constituents of the short grass prairie, buffalo (*Buchloe dactyloides*) *and blue grama* (*Bouteloua gracilis*), was measured every two weeks throughout the growing season. This was done by making at least five measurements of each species in each quadrat. Averages were thereby determined for the clipped and unclipped series. The differences in heights for each successive measurement was assumed to be the growth for a period of two weeks. The average total growth during one month for each species was determined by taking the sum of the two measurements made during that month.

Buffalo grass stolons have a definite effect upon the basal cover because of their ability to spread rapidly. The growth of stolons was measured every two weeks. In order to accomplish this, twenty vigorous stolons were selected for measurement within each exclosure and a 16-penny nail was placed at the growing tip of each stolon. The distance which the stolon extended past the nail at the end of two weeks was the growth made for that period. The average increase in length was assumed to be the growth made by living stolons in each pasture. On May 15, the number of living and dead stolons per square meter was determined by making 10 separate counts in representative areas throughout the pasture.

The amount of litter and debris was observed to vary appreciably in the different pastures. The amount of litter and debris in pounds per acre was determined in each of the pastures. This material was collected by hand from representative square meter areas and the average weight was taken as the amount found throughout the pasture. Litter was assumed to be that old vegetative material that forms a compact mulch on the surface of the soil, while debris was assumed to be the old vegetative growth, including old flower stalks, that lies loosely strewn about on top or intermixed with the new growth of grass.

The seasonal rainfall was obtained by placing two rain gauges at centrally located points. The average of the two gauges was assumed to be the rainfall for all of the pastures studied. Daily temperature records were obtained from G. W. Matthews of the U.S. Weather Bureau Station at Quinter, Kansas, about seven miles west of the areas under study. The mean temperature for each month was computed and compared with the normal mean for that period.

The total amount of soil moisture was determined every two weeks to a depth of five feet by the use of a geotome. These determinations were made on all pastures. Monthly computations were made from an average of the two bi-weekly samplings.

The hygroscopic coefficients* for somewhat similar soils at Hays, Kansas, were used for determining the available moisture at the depths of 0-6 inches, 6-24 inches, and 24-60 inches. Hays is about 48 miles east of Collyer and the hygroscopic coeffieients are not exact the same but they are sufficiently similar for the purpose of this study. The total soil moisture minus the hygroscopic coefficient of the soil was assumed to approximate the amount of soil moisture that is available for plant use.

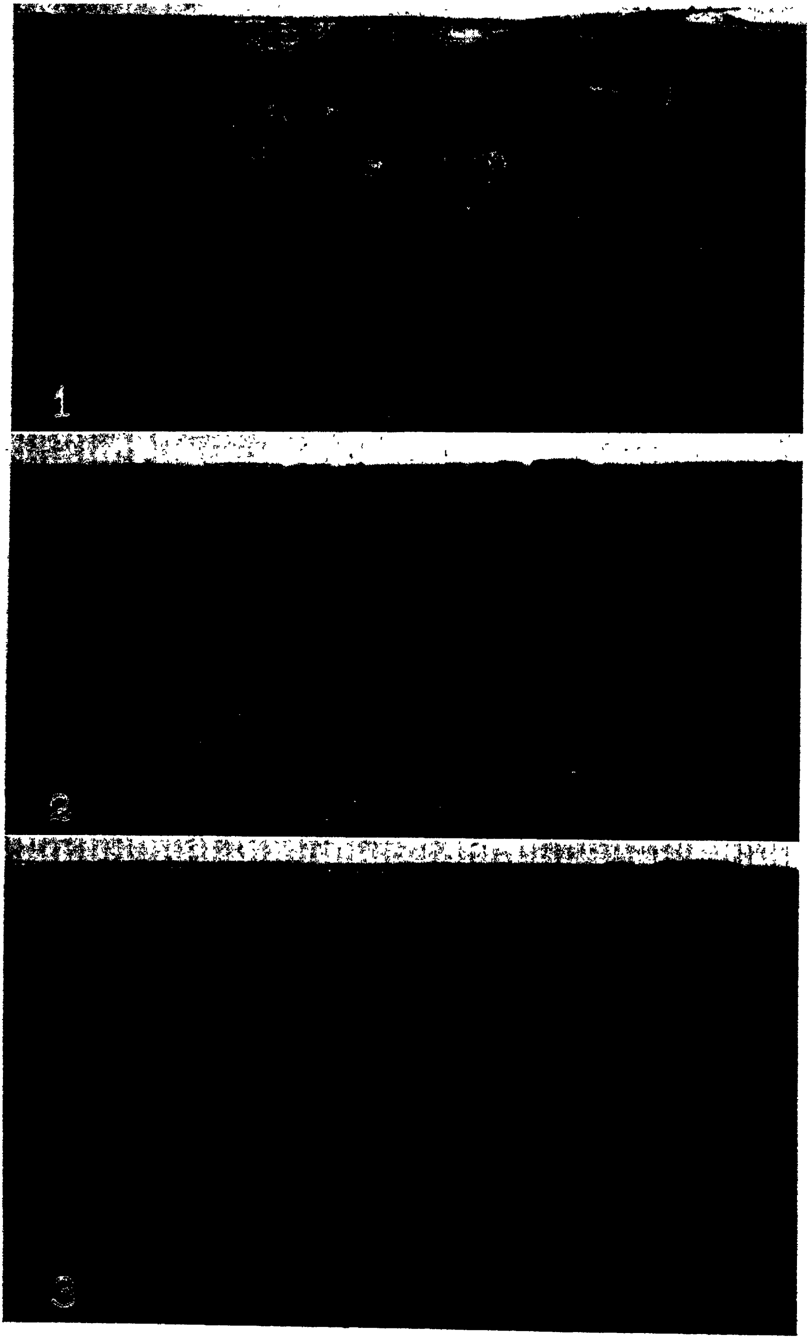
Results

History and Description of Pastures Studied

The pastures selected for study are located near Collyer, Kansas, which is about 100 miles east of the Colorado state line and 90 miles south of the Nebraska state line. The elevation is approximately 2580 feet above sea level. All five pastures lie within an area five miles in diameter and on typical gently rolling terrain with similar upland soils of the Holdrege series.

The pastures of this region have gone through many striking changes in response to extreme variations in the environment. During the drought period from 1933 to 1940, the vegetation of the native prairie was reduced to a few relicts with many new undesirable plants gaining possession (Weaver and Albertson, 1944). During the six normal or above-normal years that followed the drought the pastures recovered very rapidly. Those that were bare required much longer to recover than the ones with only scattered remnants of the original vegetation. Even the nearly bare pastures made a comparatively quick recovery because of the rapid spread of buffalo grass. This was especially true if these areas were subjected to moderate or heavy grazaing which removed the competition of weedy annuals.

*Hygroscopic coefficient—a term used to designate the amount of water the soil can take up from an approximately saturated atmosphere at a constant temperature when exposed in a layer about 1 millimeter in thickness. A soil which contains no more water than the hygroscopic coefficient is regarded as incapable of yielding water to plants. Any amount over the hygroscopic coefficient, therefore, is available for plant use.



Pasture number 1 contains 60 acres and was classified as ungrazed. During the drought years (1931 to 1940) it supported two saddle horses for approximately three months out of the year and from 1940 to 1946 the pasture was ungrazed. Before the drought a heavy stand of buffalo and blue grama grass grew on the uplands, with big bluestem (*Andropogon furcatus*) occupying the lowlands and buffalo wallows. During the dry years, however, all of the bluestem disappeared and the lowlands were invaded by the short grasses and western wheat grass (*Agropyron smithii*). Considerable dusting* also occurred on the uplands which laid bare large areas and killed much of the short grasses, giving the pasture a "patchy" appearance. Many kinds of undesirable weedy annuals, principally sunflowers (*Helianthus annuus*) and lamb's quarters (*Chenodopium album*), invaded these areas. The shading effect of these rank weeds added to the detrimental effect of dust which killed some of the grass and thereby made the bare areas even larger. Despite these conditions the grass retained enough cover to insure good pasturage during the years of drought. During the good years that followed the drought the pasture gradually improved, but there were still many bare areas. Pastures of this kind are at present fairly common in this community. At the beginning of the study the principal grasses found on the uplands were buffalo and blue grama grass, but scattered plants of sand dropseed grass (*Sporobolus cryptandrus*) and Texas crab grass (*Schedonnardus paniculatus*) occurred in the open areas. These grasses were very tall and formed a high foliage cover but close examination revealed that numerous open spaces occurred between the clumps of grass (Fig. 1). The common native forbs of these area were plentiful throughout the pasture.

Pasture number 2, the undergrazed location of 130 acres, had been subjected to a varied grazing program, but over the period of 15 years it was considered to be underutilized. From 1931 to 1940 it carried from 5 to 10 head of cattle on a six months basis. The pasture was moderately grazed during the growing seasons of 1940 through 1943 with about 25 head of cattle, but for the past three

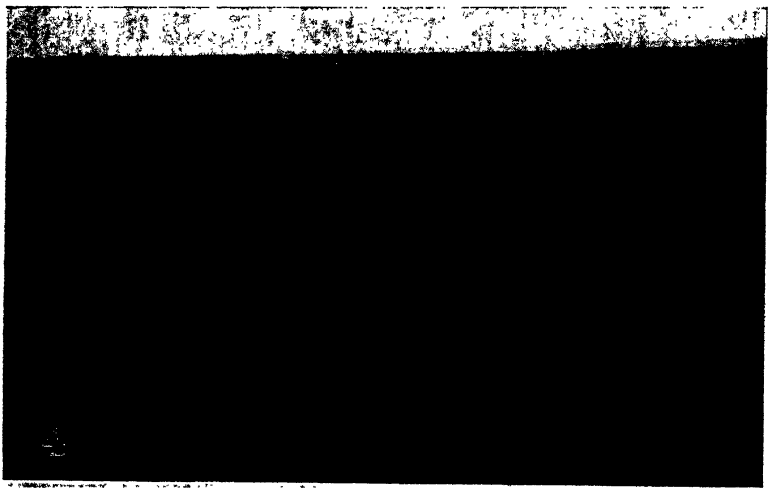
*Dusting—A colloquial term used to describe the covering of vegetation by wind blown dust.

Fig. 1. General view of pasture number 1, the ungrazed location. Many large areas throughout the pasture were covered with weedy annuals. The irregular dark patches in the foreground are bare areas between the cover of short grasses.

Fig. 2. In the undergrazed pasture, spot grazing was evident as shown by the lighter colored areas. Many weedy annuals began to appear in areas not covered by the short grasses.

Fig. 3. Pasture number 3, the moderately grazed location, had an almost solid cover of grass.

years there have been only 5 head of milk cows grazing during the growing season. Before the drought a solid cover of buffalo and blue grama grass was found on the uplands throughout the pasture. During the following dry years the cover of grass steadily decreased and the bare spaces became larger and more numerous. When a little rain did fall a large number of weeds appeared which, due to the shade they cast, helped kill the nearby grasses. A small amount of



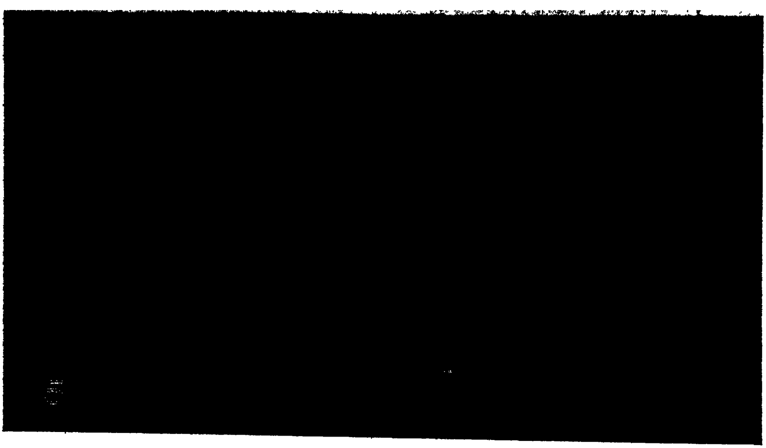


Fig. 4. General view of pasture number 4, the overgrazed location. The short grasses were closely grazed. Many bare areas, like those apparent in the foreground, were common throughout the pasture.

Fig. 5. The grass in pasture number 5, the heavily grazed location, seldom exceeded an inch in height and was generally less than .5 of an inch tall.

spot grazing was found where only favored areas were utilized, while the remainder of the pasture was undisturbed (Fig. 2). The intensity of grazing became lighter at greater distances from the farm buildings. The pasture contained numerous open spaces that were covered by mats of old grass and many little weedy annuals were beginning to appear in these open spaces.

Pasture Number 3, the moderately grazed location, contains 80 acres and had an average stocking rate of 15 animal units on a basis of 6 months. The stocking rate during the drought was much less than during good years that followed. It had a solid cover of grass until the dust storms of 1935. During these "black blizzards" and subsequent years much of the grass disappeared leaving only widely scattered clumps which furnished considerable forage. At no time, however, did the pasture have the appearance of a cultivated field as did those that were more heavily utilized. A few weeds appeared between the clumps of grass, especially in 1937 and 1938. Gains in the cover of grass were also made on nearby pastures in 1937 and 1938 but considerable losses occurred again in 1939 (Weaver and Albertson, 1944). After 1940, when soil moisture was plentiful, the original amount of cover was quickly restored. When the study was initiated, pasture number 3 appeared to be uniformly grazed with about 30 per cent of the area left undisturbed (Fig. 3). There was a good cover of vegetation composed of scattered, vigorous blue grama plants surrounded by a mat of buffalo grass. The few open spaces were well protected by a layer of old growth. Very few weeds appeared except in areas that were dusted heavily. The forbs native to this area were plentiful throughout the pasture.

Pasture number 4, the 77 acre overgrazed site, was stocked with 30 head of cattle from 1931 to 1940; 35 to 40 head from 1940 to 1945; and 20 head in 1945. The pasture was grazed every month of the year with some supplemental feed furnished during the winter. Although it was grazed fairly short before the drought it formed a solid cover with very few weeds but as the drought continued the cover was reduced so that by 1937 the pasture resembled a weedy cultivated field. When the years of normal rainfall returned, however, the cover of natural vegetation was gradually restored. Recovery was slow at first due to the sparseness of the vegetation but, the rate of spread became accelerated as the cover became more dense and by the end of the growing season of 1945, the buffalo grass stolons formed nearly a solid cover. At the beginning of the study the pasture had a cover of closely grazed grass with numerous small bare spaces between the areas occupied by buffalo grass (Fig. 4.)

The plants of buffalo grass varied in size but for the most part they were small and occurred at intervals along the stolons where roots anchored the runners to the ground. Upon close examination the cover was found to be a mass of intermingled stolons. There was evidence of some sheet erosion around these small clumps of vegetation.

Pasture number 5, classified as heavily grazed, contained 80 acres which carried 40 head of cattle on a year-round basis for the past 15 years. This area had a fair cover before the drought but was always kept very short. During the first two years of drought (1933 and 1934) most of the short grasses were killed and at the close of the dust storms in 1935 the cover was reduced nearly to nil. Often tufts of short grass .5 to 2 inches in diameter were spaced at distances of several yards. Many weeds filled the pasture until the last two or three years when the rapid growth of numerous buffalo grass stolons nearly covered the ground. At the beginning of the study the grass in this pasture was very short, sometimes less than .5 of an inch and nearly always less than 1 inch tall (Fig. 5). The cover was almost entirely buffalo grass stolons rooted down at intervals. There were very few native forbs. The unpalatable, drought resistant salmon-colored mallow (*Malvastrum coccineum*) made up the bulk of the forb population of the pasture. Many bare spaces were present with a considerable amount of sheet erosion.

Environmental Conditions During Period of Study

The total rainfall for the growing season of 1946 (April to September, inclusive) was 16.65 inches which is about 1.24 inches above normal. For the months of June and July, however, it was considerably below average being less than half normal during the latter month. Nearly half the rainfall in 1946 came during September which commonly is near the end of the growing season for the short grasses (Table I). Above normal temperatures occurred during June and July when rainfall was low (Table I).

Table I. The temperature and rainfall for the growing season of 1946 at Collyer, Kansas.

Temperature (Degrees F.)

Month	April	May	June	July	Aug.	Sept.
Mean '46	58.4	56.8	73.2	79.2	75.0	66.3
Normal Mean	51.6	63.0	72.0	79.0	76.6	68.0
Deviation	+6.8	—5.2	+1.2	+0.2	—1.6	—1.7

Rainfall (Inches)

1946		2.93	2.54	1.25	2.58	7.00
Normal	2.05	2.81	3.29	2.80	2.38	2.08
Deviation		+0.12	—0.75	—1.55	+0.20	+4.92

All pastures had soil moisture available for plant growth to a depth of two feet during the first three months (Table II). The greatest amount was found in the first six inches. The moderately grazed pasture had a plentiful supply for that period, with 10 to 20 per cent available. The other pastures contained considerably less, with slightly more in the ungrazed and undergrazed locations than was found in the overgrazed and heavily grazed sites. The major portion of the drought occurred in July which resulted in a much decreased soil moisture content. No moisture was available in the overgrazed and heavily grazed pastures to a depth of 12 inches, while only slight amounts were present in the other three areas. In the second foot of soil only the moderately grazed pasture had any

TABLE II. Approximate percentages of available soil moisture to a depth of 5 feet for all pasture types during the six summer months, 1946.

Depth	Location	April	May	June	July	Aug.	Sept.
0- 6"	Ungrazed	8.5	12.4	8.2	.2	5.6	14.9
	Undergrazed	10.5	13.2	5.4	.5	5.0	18.0
	Mod. Grazed	14.6	19.8	12.3	2.7	7.7	19.0
	Overgrazed	3.1	14.1	7.3	—1.4	—0.1	14.1
	Heavily Grazed	4.6	14.1	6.0	—0.4	0.2	14.7
6-24"	Ungrazed	6.8	2.3	0.7	—1.5	0.3	5.1
	Undergrazed	8.2	6.5	4.6	0.1	0.4	4.6
	Mod. Grazed	12.6	11.2	9.9	2.3	2.7	5.0
	Overgrazed	1.6	4.1	4.3	—0.8	—0.9	1.8
	Heavily Grazed	5.0	5.4	1.8	—1.6	—0.7	4.4
24-60"	Ungrazed	—2.3	—2.3	—2.8	—2.8	—3.0	—3.2
	Undergrazed	—0.6	—1.6	—1.3	—1.4	—0.9	—2.6
	Mod. Grazed	2.6	0.9	0.2	—0.9	—1.7	—1.4
	Overgrazed	—3.1	—3.0	—3.1	—3.4	—3.4	—3.0
	Heavily Grazed	—2.0	—2.9	—3.8	—3.8	—2.8	—2.6

appreciable amount of moisture. Although the rainfall in August was above normal the soil moisture was practically unavailable to a depth of two feet in the overutilized pastures as compared to a percentage of 5 to 7 per cent available at the other three locations. The rainfall in September was nearly 5 inches above normal, which again restored available moisture to two feet in all pastures. The first six inches carried a very high percentage of the moisture. No water was available from a depth of 2 to 5 feet for any month in any of the pastures except for a slight amount during the first half of the season at the moderately grazed location.

With hardly an exception, available soil moisture was most plentiful at the moderately grazed location. The soils of the underutilized pastures consistently held more moisture than was found in the pastures that had been overutilized.

Basal Cover and Composition of the Vegetation

The average basal cover of the twenty quadrats pantographed in the ungrazed pasture was 52.9 per cent (Fig. 6). This included 31.1

per cent of buffalo grass and 21.6 per cent of blue grama, with only a trace of sand dropseed and Texas crab grass. The cover was composed of large clumps of blue grama and mats of buffalo grass with very few stolons. Numerous bare spaces were found in the center

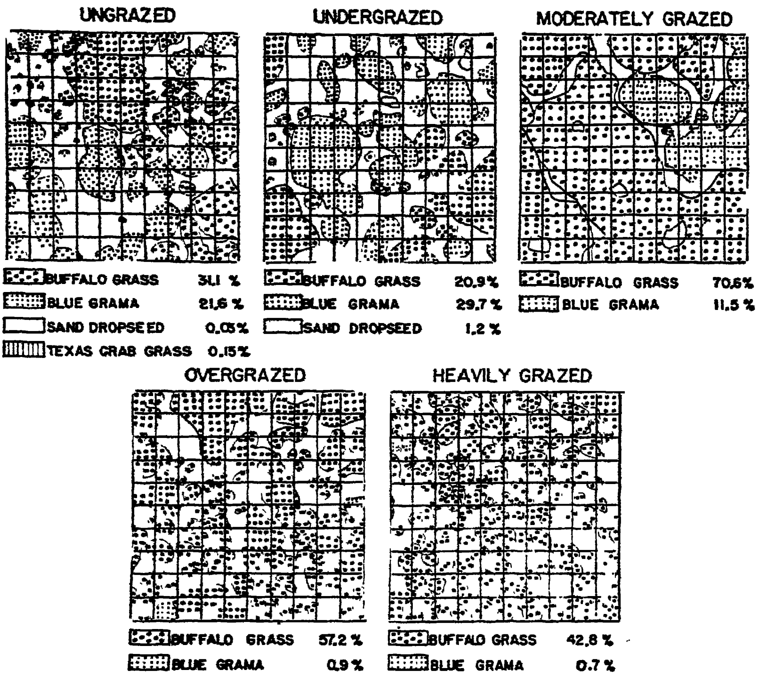


Fig. 6. Basal cover of each species of perennial grass on typical square meter areas in the different pasture types.

of the blue grama plants. Seventeen different spacies of native forbs were identified and an average of 29.8 plants were counted per 100 square feet (Table III). The principal forbs were the salmon-colored mallow, few flowered psoralea (*Psoralea tenuiflora*), wild onion (*Allium nuttallii*), and scarlet gaura (*Gaura coccinea*).

The total basal cover in the undergrazed pasture was 51.8 per cent. Blue grama was the principal grass having a cover of 29.7 per cent as compared with 20.9 per cent for buffalo grass. Sand dropseed grass was fairly common with an average cover of 1.2 per cent. This pasture supported more native forbs than any of the others, having an average of 39.5 plants per 100 square feet. There were, however, only 12 different species, most important of which were the few flowered psoralea, ragweed (*Ambrosia psilostachya*), wild onion, salmon-colored mallow and scarlet gaura.

The moderately grazed pasture had a heavy stand of grass with an average basal cover of 82.1 per cent. Although blue grama comprised only a small part of the total cover (11.5 per cent), the scattered plants were healthy and vigorous. Almost all of the area be-

TABLE III. Average number of each species of native forbs per square meter in each pasture type.

Exclosure Number	I	II	III	IV	V
Astragalus mollissimus				.4	.7
Malvastrum coccineum	12.1	4.9	12.1	1.5	4.1
Psoralea tenuiflora	6.5	10.8	3.9	.2	.5
Gaura coccinea	2.7	3.8		.1	
Allium nuttallii	3.3	6.2	1.5	.4	.2
Sideranthus spinulosus	.9	.2			
Gutierrezia sarothrae	.6				
Ratibida columnaris	1.8	.3	2.5		
Lygodesmia juncea	.3				
Aster multiflorus	.1		.2	3.2	
Astragalus shortianus	.2		.2		
Liatris punctata	.1			.2	
Callirrhoe involucrata	.6	.3		1.6	1.1
Vernonia baldwini	.2				
Opuntia macrorrhiza	.1		.4	.8	2.
Hymenopappus corymbosus	.1		.1		
Rumex altissimus	.1		.1	.1	
Polygonum ramosissimum	.1		.3	.2	
Ambrosia psilostachya		10.7	4.4	.2	1.4
Anemone caroliniana		2.0	4.5		
Cirsium undulatum		.1		.4	
Meriolix serrulata		.1			
Astragalus missouriensis		.1		.1	
Cogswellia macrocarpa			1.4	.7	
Solidago mollis				.2	
Artemisia kansana			.9		
Verbena bipinnatifida				.6	.1
Total No. of Forbs	29.8	39.5	32.5	10.9	8.3

tween these plants was covered with buffalo grass. Native forbs were numerous throughout the pasture, averaging 32.5 plants per 100 square feet, which included 14 species. The predominant forbs were salmon-colored mallow, wind flower (*Anemone caroliniana*), ragweed, few flowered psoralea, and prairie cone-flower (*Ratibida columnaris*).

The basal cover of 58.1 per cent in the overgrazed pasture was made up of 57.2 per cent of buffalo grass and the remainder was composed of blue grama and a trace of sand dropseed. It is significant to note that the tufts of grass were very small, which allowed many bare spaces to exist between the clumps. The native forb population of the pasture was relatively small, with only 10.3 plants per 100 square feet, but comprised 17 different species. The principal forbs were the many flowered aster (*Aster multiflorus*), salmon-colored mallow, and the prickly pear cactus (*Opuntia macrorrhiza.*).

Of the total cover of 43.6 per cent found in the heavily grazed pasture, buffalo grass formed 42.8 per cent. The few relict blue grama plants formed a cover of only .7 per cent. The numerous small clumps shown in Figure 6 represent the rootings of stolons as they

spread out to cover the ground. Only about one-fourth as many native forbs (8.3 per 100 square feet) were found here as compared to the number found in the moderately grazed pasture. Of the eight different species of forbs the most common were salmon-colored mallow, ragweed, and purple poppy mallow (*Callirhoe involucrata*).

Yields of Dry Forage

Seasonal Yields

In the ungrazed pasture the total yield from the quadrats clipped each month was 2438 pounds per acre (Fig. 7). On the unclipped

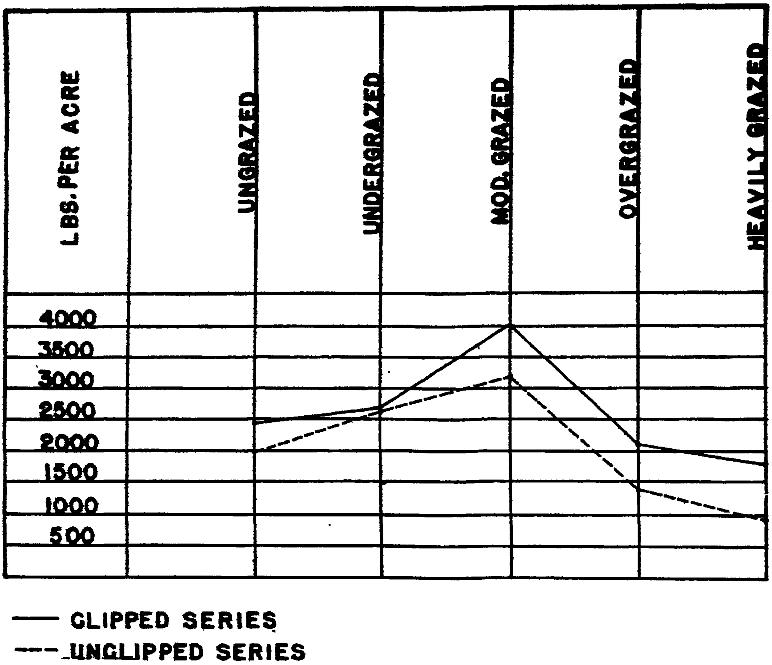


Fig. 7. Average seasonal yield of short grass in pounds per acre for the clipped and unclipped series of quadrats in each pasture.

series (clipped at end of season) it was only 1988 pounds per acre, or 81.6 per cent of the amount from the clipped quadrats.

The average amounts of forage produced from the two treatments on the undergrazed location were nearly the same, being 2686 pounds per acre on the clipped series and 2659 pounds for the other group.

The moderately grazed pasture had a forage production of approximately two tons (4001 pounds) per acre in the clipped series. Only 79.7 per cent as much (3192 pounds) was collected from the unclipped group.

On the overgrazed area an average of 2090 pounds of dry forage was produced in the quadrats that were clipped each month. About two-thirds of this yield or an average of 1388 pounds was collected in the unclipped series.

On the heavily grazed pasture the yield for the clipped series was 1774 pounds but only 941 pounds per acre on the unclipped group.

Monthly Yields

In the ungrazed pasture, the monthly productions were 723, 839, 460, 233, 143, and 38 pounds per acre, respectively, from April to September, inclusive (Fig. 8). Approximately 81.8 per cent of the total yield was produced during the first three months.

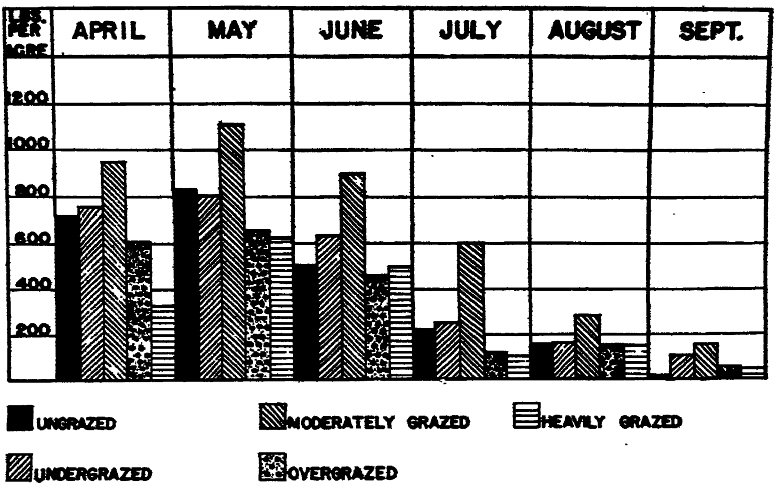


Fig. 8. Average yield of short grass in pounds per acre for each month of the growing season in all pastures.

May was the highest producing month (800 pounds) in the undergrazed pasture, followed by April (757 pounds) and June with 626 pounds, making a total for the three months of 2183 pounds or 81.7 per cent of the production for the entire season. The yield decreased each month after June, with only 241 pounds in July, 152 in August and 107 in September.

In the moderately grazed pasture, 1111 pounds per acre of forage were collected in May as compared to the low of 144 pounds in September. Over 900 pounds were produced during both months of April and June. July followed with 608 pounds while August yielded

only 271 pounds. Nearly three-fourths (74.4 per cent) of the total yield was produced during the first three months.

The overgrazed pasture yielded 612, 656, and 460 pounds per acre, respectively, for April, May, and June. The yield for these three months represented 86.0 per cent of the total for the season. The production dropped to 134 pounds in July followed by a slight rise in August (164 pounds) and then a decrease to only 53 pounds in September.

During the months of April, May and June 1340 pounds were produced in the heavily grazed pasture representing 75.5 per cent of the total yield. The monthly productions in the order of their occurrence were, respectively, 374, 616, 499, 121, 166, and 44 pounds per acre.

Correlation Between Basal Cover and Yield

Examination of the data presented in Table IV shows only a general correlation between basal cover and seasonal yield. The pounds of forage per 1 per cent cover ranged from 34 for the overgrazed to 52 for the undergrazed pasture. The more heavily utilized locations had less production in relation to cover than did any of the other three areas. This indicates that the growth of grass in height must also be considered as a factor in the production of forage. The larger amount of forage in relation to cover in the undergrazed pasture as compared to the moderately grazed location indicates that other factors besides cover and the height of grass play a part in production.

TABLE IV. A comparison of the basal cover and seasonal yield of the short grasses in the five pasture types.

Pasture Type	I	II	III	IV	
Basal Cover	52.9	51.8	82.1	58.1	43.6
Seasonal Yield*	2438	2686	4001	2009	1774
Pounds of Forage per 1 per cent Cover	46	52	49	34	40

*Sum of the monthly yields.

Growth of Grass in Height

The results of this portion of the study are also presented in two groups, the clipped and the unclipped series. It should be remembered that the clipped series represents those areas which were harvested each month while the other group was clipped only twice, once in July and again in September.

Clipped Series

In the ungrazed pasture buffalo grass produced a seasonal increment of 8.1 inches as compared to 8.9 inches for blue grama (Fig. 9). The average total growth for both grasses was 8.5 inches, of

which 81.2 per cent occurred during the first three months. The monthly increment ranged from 3.4 inches in April to .15 of an inch in September (Fig. 10).

The total season's growth in the udergrazed pasture was 8.5 inches for buffalo grass and 10.3 inches for blue grama. The average

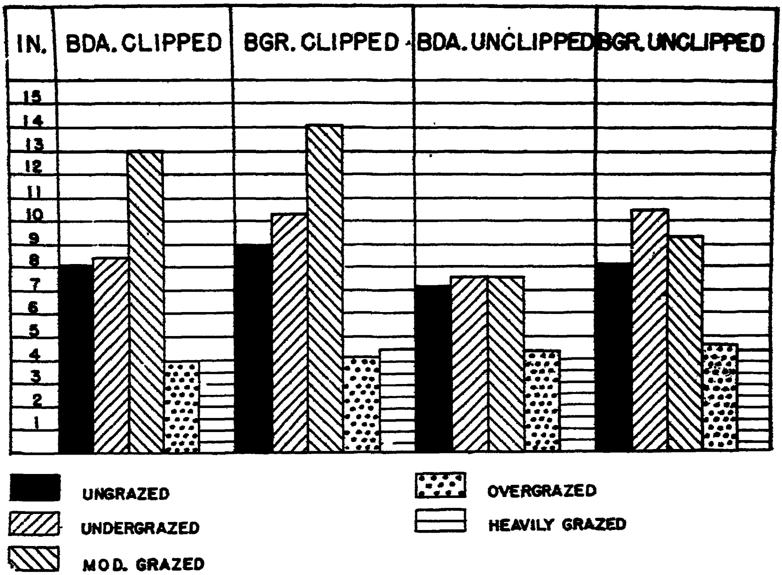


Fig. 9. Seasonal growth of buffalo (Bda) and blue grama (Bgr) in inches, for both the clipped and unclipped series of quadrats on all pastures.

of the two was 9.4 inches with 87.9 per cent of the increment produced during the first three months. Growth of both grasses was greater during April with 3.1 inches after which there was a gradual decrease until the low of .18 of an inch occurred in September.

The average total growth in the moderately grazed pasture was 13.6 inches comprising 13.0 inches for buffalo grass and 14.1 inches for blue grama. Slightly over two-thirds of the total increment (66.8 per cent) occurred during the first half of the growing season. The increment varied from the highest of 3.5 inches in May to the lowest of a little less than .4 of an inch in September.

The growth of grasses in the overutilized pastures was considerably less than the increment found at the other locations. The increment in the overgrazed pasture was 4.0 inches for buffalo grass and 4.2 inches for blue grama. Over three-fourths of this growth (79.3 per cent) was made during April, May, and June. The great-

est increment occurred during the first month, with 1.3 inches, but thereafter it gradually diminished each month to only .11 of an inch in September.

In the heavily grazed pasture, buffalo grass grew 3.6 inches as compared to 4.5 for blue grama, making an average total increment for the season of 4.1 inches. Of this total 74.7 per cent was pro-

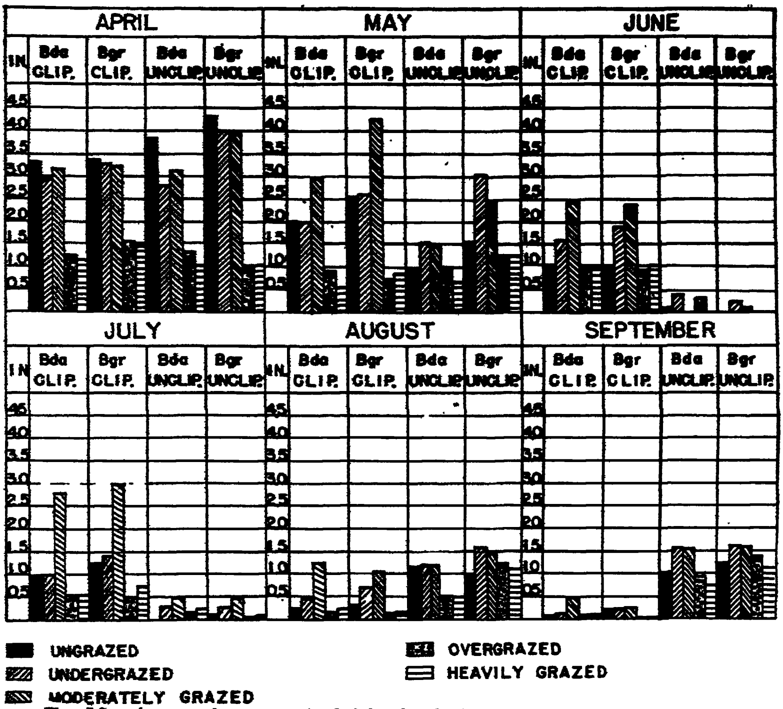


Fig. 10. Average increment in height for both short grasses from the clipped and unclipped areas of the five pastures for each month of the growing season.

duced during the first three months. The growth became successively less from April, with 1.32 inches, to .1 of an inch in September.

Unclipped Series

Since a clipping was made the last of July and thereby furnished some stimulus to the growth in this series only the comparison of seasonal increments is given.

In the ungrazed pasture the total increment for the short grasses was 7.7 inches. Blue grama made a growth of 8.2 inches as compared to 7.2 for buffalo grass (Fig. 9).

The average total increment of both grasses in the undergrazed pasture (9.0 inches) was greater than that found at any of the other

locations because of the exceptional growth of 10.5 inches for blue grama. For buffalo grass it was 7.5 inches.

The moderately grazed pasture produced an average increment of 8.4 inches for the season. Blue grama again made the greatest growth with 9.3 inches as compared to 7.5 inches for buffalo grass.

The total increment in the overgrazed pasture was 4.5 inches. Very little difference was found between the growth of blue grama (4.7 inches) and buffalo grass (4.3 inches).

The heavily grazed location produced an average total increment of only 3.9 inches. Blue grama made the greatest growth with 4.4 inches as compared to 3.3 for buffalo grass.

Correlation Between Yield and Increment

As indicated in Figure 11 a general correlation exists between

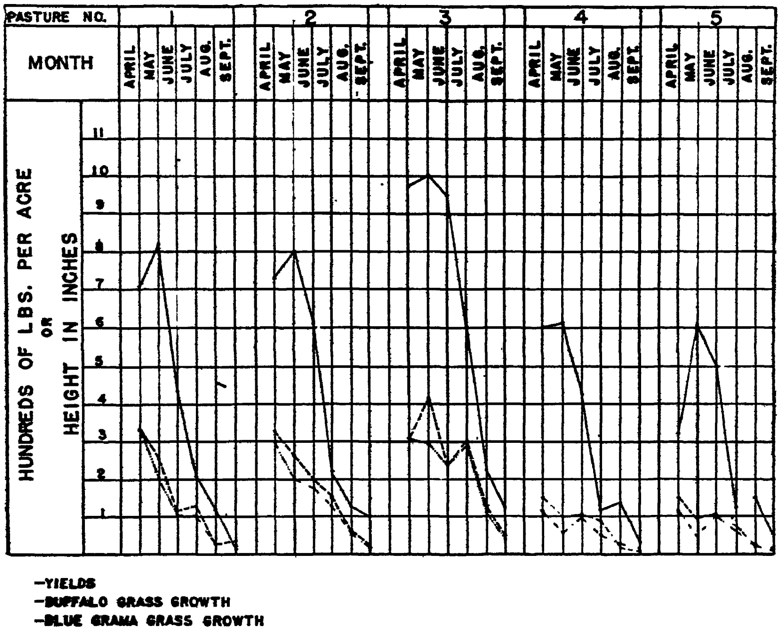


Fig. 11. Correlation between the growth of the short grasses in height and the production of forage for the six summer months at the different areas.

the inches of growth and the amount of forage produced by the short grasses.

The amounts of forage and increment produced during the first three months were similar in all pastures. The percentages of total increment for the first three months in pastures 1 to 5 were, respectively, 81.2, 87.9, 66.8, 79.3 and 74.7. The percentages of yield for

the same period, in the same order of pastures, were 81.8, 81.7, 74.4, 86.6 and 75.5.

At all locations an increase in yield from April to May was accompanied by a decrease in increment, but both yield and increment decreased with slight exceptions from May to September. For example, an increase in increment for the grasses in the ungrazed and moderately grazed locations occurred from June to July and the yield continued to decrease. In the overutilized pastures an increase in increment was accompanied by a decrease in yield from May to June while the reverse was true in both pastures from July to August. These exceptions from the general correlation suggest that factors other than growth in height enter into the production of forage.

Growth of Buffalo Grass Stolons

The rapid spread of buffalo grass stolons played an important role in the recovery and maintenance of the vegetative cover in the short grass prairies.

An average of 73 stolons per square meter was counted in the ungrazed pasture and of these 19 per cent were dead (Table V). The average total growth made by the stolons during the period of study

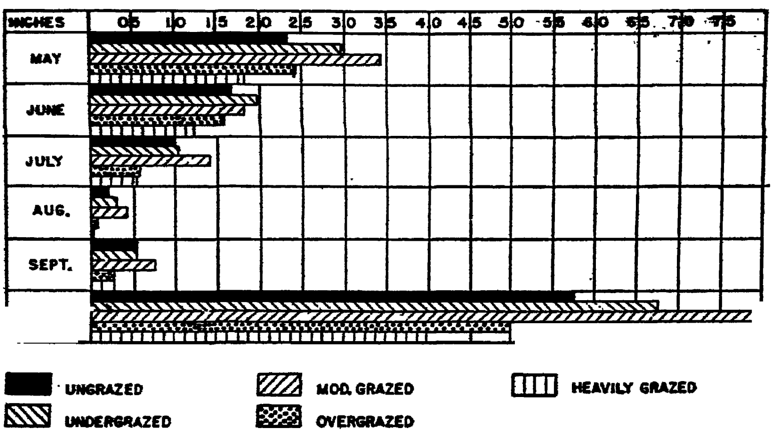


Fig. 12. Average growth of buffalo grass stolons in inches on each pasture.

was 5.75 inches (Fig. 12). The greatest and least increments occurred in May and August, respectively.

The undergrazed pasture contained a total of 78 stolons per square meter, of which 13.6 per cent were dead. The stolons made a total growth of 6.75 inches for the season which included increments

TABLE V. The number of live and dead buffalo grass stolons found per square meter in each pasture.

Pasture Type	No. of Lives Stolons	No. of Dead Stolons	Total No. of Stolons	% of Live Stolons	% of Dead Stolons
Ungrazed	59	14	73	80.8	19.2
Under-Grazed	66	12	78	86.4	13.6
Moderately Grazed	171	27	198	86.4	13.6
Over-Grazed	558	81	639	87.4	12.6
Heavily Grazed	378	63	441	85.7	14.3

of 2.95, 1.95, 1.05, .3 and .55 inches, respectively, for May, June, July, August and September.

Of the average of 198 stolons per square meter in the moderately grazed pasture, 13.6 per cent were dead. The greatest growth of stolons in any of the pastures was made at this location, averaging 7.95 inches for the season. The monthly growth became progressively less from the high in May (3.4 inches) to the low in August (.4 of an inch). The heavy rains in September brought the increment up to .75 of an inch.

The overgrazed pasture had the greatest number of stolons per square meter (639) and only 12.6 per cent of them were dead. Monthly increments were 2.4, 1.6, .6, .1 and .3 inches, respectively, for May, June, July, August and September, making a total increment of 5 inches.

In the heavily grazed pasture, 14.3 per cent of the 441 stolons found per square meter were dead. Only 4 inches of growth were produced by the stolons from May to September, inclusive. An increment of 1.8 inches was produced in May as compared to only .05 of an inch in August.

Litter and Debris

The ungrazed pasture had a surface layer of partially decomposed litter approximately 3.7 inches in depth which averaged 2004 pounds per acre (Fig. 13). The undergrazed pasture produced slightly less than this with 1789 pounds to an average depth of 2.9 inches, while on the moderately grazed location the amount was only 930 pounds to a depth of 1 inch.

The amount of litter found in the overutilized pastures was insignificant, with only 49 and 30 pounds per acre, respectively, on the overgrazed and heavily grazed locations. Small areas scattered throughout the pastures were covered to a depth of approximately .5 of an inch while the major portion of the soil was bare.

The amount of debris was much greater on the ungrazed pasture

than in the other areas (Fig. 13). An average of 1928, 952 and 524 pounds per acre, respectively, was collected from the ungrazed, undergrazed and moderately grazed locations. Because of the extreme-

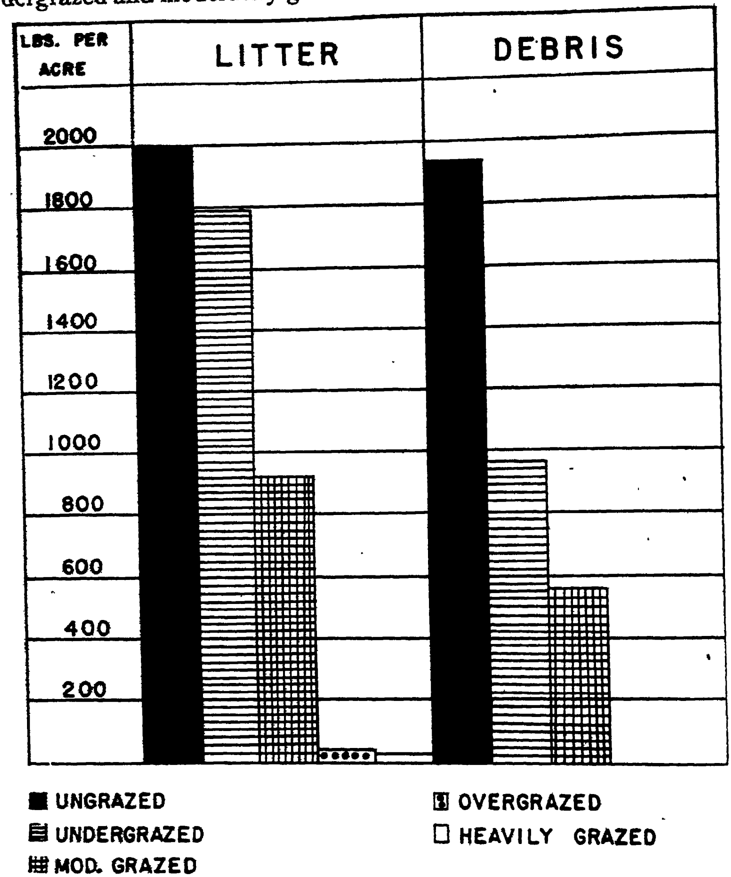


Fig. 13 Amount of litter and debris in pounds per acre for each pasture type.

ly close cropping of the grass no debris was present on either the overgrazed or heavily grazed pastures.

Discussion and Summary

Pastures which have been subjected to different intensities of grazing exhibit definite characteristics which reflect their past treatment. Five pastures were selected for study with reference to their history of grazing for the past 15 years and were classified as ungrazed, undergrazed, moderately grazed, overgrazed and heavily grazed. Some of the characteristics of these areas were studied dur-

ing the growing season of 1946 and a short discussion of the results will help to evaluate them. A comparison of the pastures was made along the following lines: (1) basal cover and composition of the vegetation; (2) monthly and seasonal yields of air-dried forage; (3) growth and number of buffalo grass stolons; (4) growth of the grasses in height; and (5) amount of litter and debris present at each location.

The principal limiting factor in the growth of vegetation in the Great Plains area is the amount of soil moisture available to the plants. Consistently more moisture was available for plant growth in the pasture which had been moderately grazed than was found on the underutilized and overutilized pastures. The variation in the amount of soil water in the pasture types might be accounted for through some of the effects of past treatment. More moisture enters the soil on which it falls if the ground has a good basal cover and sufficient litter and debris to absorb the water and retard runoff. Water is lost from the soil primarily by transpiration from the leaves of plants and by evaporation from the surface of the soil. In overutilized pastures the soil between the living plants was unprotected which allows a high rate of evaporation, but on underutilized pastures it was protected by a dense layer of old vegetation which reduced evaporation to a minimum. On the latter types of pastures, however, the larger amount of leaf surface left exposed throughout the season probably resulted in a greater rate of transpiration. The moderately grazed area has enough litter and debris to cover the few bare spaces and it was utilized sufficiently to retard excessive transpiration. This ability of the moderately grazed location to retain more of its soil moisture partially explains the results of this study.

The cover of perennial grasses on the moderately grazed pasture was nearly twice that found at the other locations. The total cover of short grasses was nearly the same for the underutilized and overutilized pastures, but the composition was very different. On the former location about equal amounts of buffalo and blue grama grass were found, while on the latter the cover was practically all buffalo grass. The composition of the vegetation on the moderately grazed pasture was found to be intermediate with 70.6 per cent cover for buffalo grass and 11.5 per cent for blue grama.

Several reasons might be advanced for these conditions. Although blue grama is the most drought-resistant, buffalo grass endures closer grazing than does blue grama because of the greater amount of leaf surface close to the ground in the former species.

The fact that buffalo grass had the ability to spread rapidly by means of stolon growth might also account for the large amounts of that grass in the overutilized locations. The abundance of old growth in the underutilized pastures hinders the growth of these stolons. They tend to grow either on top of the litter and debris where they cannot establish roots or under the old growth where the lack of sunshine kills them. This accounts for the relatively few stolons found in the areas with heavy debris.

No appreciable difference was found in the native forb population in the ungrazed, undergrazed, and moderately grazed pastures. A considerable reduction in numbers, however, was noted on the overgrazed and heavily grazed locations. The more palatable forbs such as the wild onion and few flowered psoralea became fewer as the degree of utilization increased. Heavier grazing practices seemed to decrease the forb population about one-third. The salmon-colored mallow, being unpalatable and very drought-resistant, was the most prevalent forb in all pastures.

The highest seasonal yield of short grass in pounds per acre was produced in the moderately grazed pasture, followed in the order of their yields by the undergrazed, ungrazed, overgrazed, and heavily grazed locations. Nearly twice as much forage was produced in the moderately grazed pasture as there was in either of the two overutilized locations. Although the yield was much reduced in the underutilized pastures it was greater than that produced on the heavily stocked areas. Production was greatest in May in all pastures with over three-fourths of the yield being produced in the first three months. The production of forage in the areas that were clipped each month was greater than those quadrats of the unclipped series, which were harvested only twice during the season, indicating that clipping does initially stimulate grass yields. Generally speaking, those pastures with a denser cover of vegetation produced a greater yield, but other factors such as the growth of grass in height, production of tillers and so forth caused some variation from close correlation.

The greatest growth of the short grasses in height was made in the moderately grazed pasture for the clipped series. The greatest increment occurred in April and the least in August and September for all pastures studied. The reduction of the increment in July, due to the drought, was not as noticeable in the moderately grazed area as it was at the other locations. In general, blue grama grass produced more growth than did buffalo grass. The stimulating effect of clipping upon the short grasses of the moderately grazed pasture

was shown by a difference of 5 inches in height between those quadrats harvested each month and those clipped only twice during the season. A difference of less than an inch was found in the underutilized pastures and hardly any difference at all occurred in the overutilized areas. In Figure 10, the differences in the monthly increments of clipped and unclipped series also illustrate this stimulating effect. After the first harvest in April, the growth in the clipped series for May, June, and July was over twice that of the unclipped series. After the unclipped group was harvested in July, the growth was much greater in that series than it was in the quadrats that were clipped each month, which indicated that the greatest stimulation occurs during the first two or three months after the initial clipping.

A very close correlation was found between the seasonal yield and the seasonal growth of grasses in height. When the monthly yields and increments were compared, however, a number of exceptions to close correlation between the two were noted. In some cases it was found that yield increased while increment decreased. During the first part of the season many new tillers developed, which would increase the yield but might even decrease the average height of the grasses. In periods of drought such as occurred during this growing season, the number of tillers decreased, which would cause an opposite effect on the relations of the two factors. During the period of seed production many buffalo grass seed burs are collected while clipping, which would raise the yield in relation to the increment in height.

The greatest number of stolons was found in the overgrazed and the least in the ungrazed pasture. There were many times more buffalo grass stolons in the overutilized pastures than were found in the other three locations. The large number of stolons was not entirely due to differences in the composition of the vegetation but to the amount of old vegetation. The growth of stolons in each of the areas studied followed the same general pattern as did the growth of tillers and total yield of grass. The total growth was greatest in the moderately grazed, followed in the order of production by the undergrazed, ungrazed, overgrazed and heavily grazed pastures. Over three-fourths of this growth was made during the first three months.

The ungrazed location contained slightly over a ton of litter, followed by nearly 1800 pounds in the undergrazed and 730 pounds for the moderately grazed area. Only 49 and 30 pounds were found, respectively, on the overgrazed and heavily grazed pastures. The

less intense the utilization of a pasture the more litter it will contain because more vegetation is left each year to decompose. Therefore an accumulation of large amounts of litter seem to indicate an under-utilized condition. Debris also may be used as an indicator but it only tells the story for one or two years because it soon begins to decompose and form litter. Nearly twice as much debris was present on the ungrazed area as on the undergrazed location and four times as much as on the moderately grazed pasture. No debris was found on the two closely grazed pastures. In an earlier discussion it was shown that a certain amount of litter and debris, as defined in this paper, is beneficial to a well managed pasture, but too large an amount can be detrimental to growth of native vegetation.

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A Raised Marsh Near Muscotah, Kansas

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Located a mile and a half south of the town of Muscotah in ıtchison County Kansas is an area of a few acres that is totally different from any other area known in the state. In this area is a raised marsh surrounded by a semipermanent swampy region, the whole of which owes its existence to artesian water. The accompanying map prepared by Duncan J. McGregor of the department of

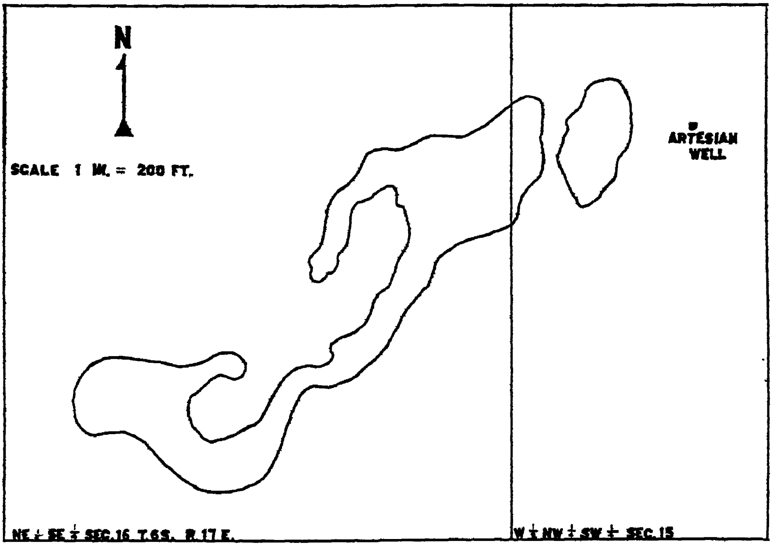

Figure 1. Outline of Raised Marsh.

geology, University of Kansas, shows the location and outline of the raised marsh. The purpose of this paper is to describe the physical aspects of the region, and to give the results of a study made of the higher plants found growing on this raised marsh and in the surrounding swampy region.

The area under consideration is found at the foot of a hill that runs along the northeast, east and south sides of the marsh. From the top of the hill, which is some 250 yards from the marsh on the south and 420 yards on the east, is a gentle slope which gradually levels out a little distance from the marsh. Along the west side of the marsh is a nearly level creek valley. The raised portion of the marsh

straight line but has a slight crescent shape with the concave side to the northwest.

At the northeast end of the marsh is an artesian well. It consists of a piece of two inch pipe fitted into a drilled hole. The top of the pipe is some seven feet above ground level. From this well a continuous stream of water flows the year round. This water is drained off to form an artificial, shallow pond a little distance to the north. The intervening area is swampy.

Perhaps the most interesting features to one visiting this unique locality are the physical aspects of the raised marsh. Its maximum height is 7 feet and it varies from 15 to 54 yards in width and is about 274 yards long. As one approaches and walks upon this raised marsh he immediately is impressed by the little pools of water found over the surface. Some of these are due to cattle tracks, others to small natural pockets formed by vegetation and several are bubbling springs. As one walks over the surface of the marsh it becomes evident that it is quite spongy. Upon jumping up and down it is observed that an area extending several feet in every direction is made to shake and quiver; water spurts out of crayfish holes and appears here and there over the surface. There is little doubt that water is constantly moving slowly upward through the mounds, though very little drainage is observed from them.

A study of the marsh revealed a soil rich in organic material and very black in color. Semidecayed plant materials consisting of roots, runs, in general, from northeast to southwest. It does not run in a stems and leaves make up a large part of the material and snail shells are everywhere abundant.

These findings led to a desire to study the nature of the raised marsh below the surface. A core made with a three inch auger revealed that the material of which the mounds are made extends down for at least 25 feet. This is not the maximum depth but is the figure that could be obtained with equipment at hand. Examination of this core revealed the presence of semidecayed plant structures and snail shells from the surface down to the 25 foot level.

The area surrounding the raised marsh exhibits seasonal aspects. In the spring and fall the marsh is surrounded by shallow water particularly on the side toward the hill slope. The side toward the creek valley is drier due to drainage away from the area. During the summer the water surrounding the mounds disappears and the dry area extends up to the very base of the raised marsh on all sides.

A study of the plants growing on the raised marsh revealed sedges to be greatly dominant. *Scirpus validus* Vahl. is certainly

the most abundant species. It is restricted to the raised marsh and does not occur on the flats. During the summer it gives the raised marsh a well defined outline especially when the marsh is viewed from a distance. The second most common plant is *Carex annectans* Bickn. which forms a thick undergrowth below the last mentioned species. This second species is also abundant in the swampy areas around the raised mounds and extends into the surrounding grassland. *Agrostis alba* L. is the dominant grass along the border of the swamp. It occurs, also, up to the edge of the raised marsh and scattered over it. A few other species occur in local patches. These are: *Cardamine bulbosa* (Schreder) BSP.; *Jussiaea diffusa* Forsk.; *Ranunculus sceleratus* L. and *Sparganium eurycarpum* Engelm.

Several species are common over the area of the marsh but are well scattered. Such plants are: *Asclepias incarnata* L.; *Lobelia syphilitica* L.; *Eupatorium perfoliatum* L.; *Helenium autumnale* L.; *Carex hyalinolepis* Steud.; *Carex vulpinoidea* Michx.; *Scirpus atrovirens* Muhl.; *Stachys pustulosa* Rydb.; *Lythrum alatum* Pursh.; *Epilobium lineare* Muhl.; *Polygonum hydropiperoides* Michx.; *Galium tinctorium* L.; and *Lippia lanceolata recognita* Fernald and Griscom.

A number of other plants have been found but have to be considered as of rare occurrence. All species found which come under this heading are included in the annotated list at the end of the paper. It must be mentioned that *Typha latifolia* L. is conspicuous by its near-absence from the area. It does occur, however, in a swampy area near the raised marsh.

Our preliminary study of this raised marsh has raised several interesting questions, the most interesting of which concerns how the structure was formed. It seems apparent that the raised mounds have been slowly built up by the accumulation of the rank vegetation which has only partially decayed. It is thought that initially the mounds were formed in a valley and as they have built up, soil has washed in from the eroding hills to fill in along the sides of the mounds. Further investigation on this question is in progress and it is hoped that taking numerous cores will enable us to ascertain the nature of the complete formation. An attempt will be made to determine the nature of the vegetation by study of pollen grains, if present, and of plant fragments found.

Other studies are being made on the area by other members of the Dept. of Botany at the University of Kansas. Mr. Frank Emerson is studying soil fungi of the marsh and Dr. Rufus Thompson is studying the algae of the area.

The following list contains all species of higher plants found in this study. The families are arranged alphabetically as are the genera and species in each family. All specimens are on file in the Herbarium at the University of Kansas.

ALISMATACEAE
Alisma subcordatum Raf.
Sagittaria latifolia Willd.

ASCLEPIADACEAE
Asclepias syriaca L.
Asclepias incarnata L.

BRASSICACEAE
Capsella bursapastoris (L.) Medic.
Cardamine bulbosa (Schreber) BSP.
Thlaspi arvense L.

CAMPANULACEAE
Lobelia syhpilitica L.

COMPOSITAE
Aster novae-angliae L.
Aster spp.
Bidens glaucescens Greene.
Eclipta alba (L.) Hassk.
Eupatorium perfoliatum L.
Helenium autumnale L.
Solidago altissima L.
Vernonia fasciculata Michx.
Vernonia interior Small

CRASSULACEAE
Penthorum sedoides L.

CYPERACEAE
Carex annectans Bickn.
Carex bicknellii Britton
Carex emoryi Dewey
Carex frankii Kunth.
Carex hyalinolepis Steud.
Carex leavenworthii Dewey
Carex meadii Dewey
Carex retroflexa Muhl.
Carex rosea Schk.
Carex vulpinoidea Michx.
Eleocharis mamillata Lindb.
Scirpus atrovirens Muhl.
Scirpus validus Vahl.

EUPHORBIACEAE
Acalypha virginica L.

JUNCACEAE
Juncus dudleyi Wiegand
Juncus torreyi Coville

LAMIACEAE
Lycopus americanus Muhl.
Nepeta cataria L.
Physostegia virginiana (L). Benth.
Prunella vulgaris lanceolata (Barton) Fernald
Stachys pustulosa Rydb.

LEMNACEAE
Lemna perpusilla Torr.

LYTHRACEAE
Lythrum alatum Pursh.

OENOTHRACEAE
Epilobium lineare Muhl.
Jussiaea diffusa Forsk.
Oenothera biennis L.

POACEAE
Agrostis alba L.
Alopecurus carolinianus Walt.
Hordeum jubatum L.
Setaria viridis (L.) Beauv.

POLYGONACEAE
Polygonum buxiforme Small
Polygonum hydropiperoides f. strigosum (Small) Stanford
Rumex crispus L.

PRIMULACEAE
Steironema ciliata (L.) Raf.

RANUNCULACEAE
Ranunculus sceleratus

RUBIACEAE
Galium aparine L.
Galium tinctorium L.

SALICACEAE
Salix nigra Marsh

SCROPHULARIACEAE
Gerardia aspera Dougl.

SOLANACEAE
Solanum nigrum L.
Solanum carolinense L.

SPARGANIACEAE
Sparganium eurycarpum Engelm.

TYPHACEAE
Typha latifolia L.

VERBENACEAE
Lippia lanceolata recognita Fernald and Griscom
Verbena simplex Lehm.
Verbena stricta Vent.
Verbena urticifolia L.

Kansas Botanical Notes, 1947, Including Species New to the State[1]

FRANK C. GATES, Kansas State College, Manhattan

The spring of 1947 was long drawn out and unsatisfactory for many types of field work. A temperature of —31° F. was reached January 4. In the latter part of the summer and early fall we experienced the most severe drouth that we have had since the famous 30's.

The low temperatures of early January killed many flower buds of flowering shrubs so that flowers appeared only from lower parts of the bushes where they had been protected by snow. This was particularly noticeable in *Rhodotypus, Kerria, Forsythia, Spiraea prunifolia, Lonicera tatarica, and Prunus angustifolia.*

A warm spell in February brought out staminate flowers on one tree of *Acer saccharinum* on February 19. Continuous freezing weather thereafter held the staminate flowers of that tree quiescent until March 6 when other trees came into blossom.

In the fall leaves were very late in falling. Leaves of *Acer plantanoides* dried on the trees instead of falling and on account of a poor separation layer remained attached until blown off by wind in December. Even then some shriveled leaves hung on clear thru the winter. We have recorded no other such case in all of the years that we have been watching these trees. Leaves of *Acer saccharinum* fell on December 6.

Celtis occidentalis, Juglans nigra, and *Asimina triloba* held their leaves long after usual time of fall until a real freeze of 12° F on November 11, 1947, caused a tremendous leaf drop of all the leaves on a single day.

But little herbarium activity was carried on during the year. Still, collections were received from miscellaneous counties during the summer, especially some from southwest Kansas by M. D. Atkins, Soil Conservationist. Mr. R. L. McGregor sent in a large collection of Douglas County plants at the end of the year.

Species New to the State

Lincoln Constance in studies of Phacelia, for which we are at the edge of the range, distinguished between *Phacelia gilioides* Brand and *P. hirsuta* Nutt., thus adding the former to the Kansas flora.

Transactions Kansas Academy of Science, Vol. 51, No. 2, 1948.

[1]Contribution No. 493, Dept. of Botany.

We have specimens from Saline, Chautauqua, Labette, and Cherokee counties.

Setaria faberi Herrm., collected by S. V. Fraser in Cloud County, Kansas, in 1945, has been identified by Miss Agnes Chase of the National Museum. This plant is a Chinese plant related to *Setaria viridis* and *S. italica,* first appearing in the United States in Missouri in 1932, then in Virginia in 1936, supposed to have come in with millet, *S. italica,* seed imported from China. It is now fairly common around Washington, D.C., and has been found in Kentucky and Pennsylvania, but this is the first record from Kansas.

Additional species new to the state were reported in the Transactions, vol. 50, pp. 200-201, by W. H. Horr and R. L. McGregor as follows: *Botrychium obliquum* Muhl (erroneously reported as *B. dissectum* Spreng.), *Ophioglossum engelmanni* Prantl, *Phegopteris hexagonoptera* (Michx.) Fee, *Filix bulbifera* (L.) Underw., *Cheilanthes lanosa* (Michx.) Wats., *Cuscuta indecora longisepala* Yuncker, *Stellaria longifolia* Muhl., *Sparganium americanum* Nutt., *Centaurea maculosa* Lam., *Orobanche fasciculata* Nutt., and *Triosteum angustifolium* L., all in the eastern fourth of Kansas.

Work Capacity of Muscles From Animals Treated With Male Sex Hormone[1]

E. H. HERRICK and RICHARD S. STORER
Kansas Agricultural Experiment Station, Manhattan

Introduction

It has often been said that male sex hormone contributes to the strength of muscles and endurance of male animals. This conclusion, although possibly valid, has relatively little experimental evidence to support it, especially when individual muscles are considered.

Hoskins in 1925 demonstrated that voluntary activity in normal rats was about 60 per cent greater than in castrate rats. Gans and Hoskins in 1926 reported that isolated gastrocnemius muscles from castrate rats did approximately 25 per cent less work than similar muscles from normal animals. Hoskins in 1927 attempted to restore the activity of castrate animals with testis grafts but the results were negative. Gans and Hoskins (1926) determined that weights of individual muscles of castrate animals were greater than those from normal ones. Papanicolaou and Folk (1938) also reported hypertrophy in the muscles of guinea pigs after treatment with testosterone propionate.

Wainman and Shipnounoff (1941) found that castration resulted in marked decrease in size of the striated perineal muscles but that these muscles could be restored to normal development by administering testosterone propionate. Simonson, Kearns, and Enzer (1941 and 1944) reported definite influences on endurance and performance in different types of work among eunochoid and castrate men treated with testosterone propionate and methyl testosterone. In normal men, however, Samuels, Henschel and Keys (1942) found no increase in work capacity after treatment with androgens. In 1945 Herrick reported that female fowls and capons treated with testosterone propionate showed approximately 30 per cent increase in the breaking strength of the gastrocnemius muscles and 100 per cent increase in the breaking strength of the skin. Chemical analyses revealed a greater amount of collagen in the tissues of treated birds.

Experiments

To test the influence of known amounts of male sex hormone on the physiological response of living muscles, frogs (Rana pipiens) were used. The animals in all cases were paired according to weight,

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[1]Contribution No. 258, Department of Zoology.

with one control and one experimental animal constituting each pair. The maximum difference in each pair of animals was four grams. One animal of each pair received testosterone propionate. The injected frogs were given five milligram injections on alternate days for seven doses; then, one day before the tests were made (the eighth injection day) an injection of 2.5 mg. was given—a total dosage of 35.5 mg. Preliminary tests indicated that intraperitoneal and intramuscular injections gave similar results. The frogs were kept in covered individual glass jars, each containing a small amount of water.

The frogs were killed as needed and the gastrocnemius muscles were removed and set up in the usual manner for muscle-nerve preparations with muscle levers, kymograph, and electric stimulating devices. In 12 pairs of frogs fatigue records were made in which the

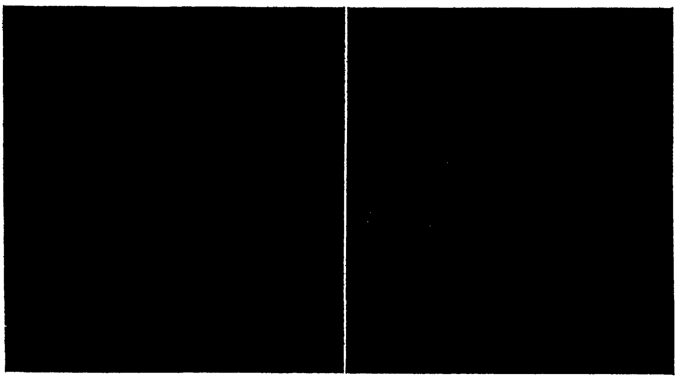

Figure 1. Kymograph records of muscles from normal and treated frogs showing fatigue.

muscle was stimulated at intervals of one second with the kymograph drum moving slowly. (Figure 1.) Since the drum moved at a uniform rate and the stimulus was repeated at known and uniform intervals, the records were evaluated on the basis of square centimeters covered.

In experimental animals the fatigue records showed an average of 58.12 square centimeters while the control animals averaged 52.78 square centimeters. This is a difference of 5.34 square centimeters in favor of the experimental animals or an increase of approximately 10 per cent over the control group.

To test the work capacity of muscles, weights were added to the muscle lever and the work computed in terms of gram-millimeters (the mass of the weight in grams times the height in millimeters it

was lifted). For each of the 15 pairs of records, the muscle was set up and a 10-gram weight was added to the muscle lever. Three contractions of the muscle were induced, then another 10-gram weight was added and records made until the muscle failed to respond.

The frogs that had received the male sex hormone averaged 1061.14 gram-millimeters of work as compared to 711.15 gram-millimeters for the control frogs. This difference of 360.99 gram-millimeters gives approximately 51 per cent greater work over the control group. The treated animals gave a greater work capacity record at all loads, as indicated in Figure 2. It will be noted that the

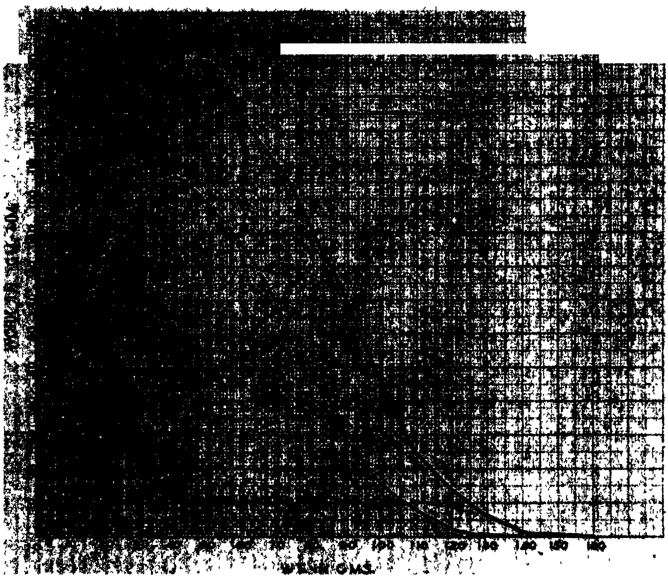

Figure 2. Work record of muscles from normal and treated frogs.

control group reached its maximum work level at a load of 40 grams, doing 106.5 gram-millimeters of work. The experimental group reached its peak of work at 50 grams doing 141 gram-millimeters of work.

In a group of 12 pairs of frogs the same procedure was followed as in the previous group except that after the muscle failed to respond with the heavy load, it was given a "rest" period of five minutes. After the rest period the muscle was again stimulated after adding weights until it failed to lift the load. Four rest periods followed by work periods were carried out for each muscle after the initial record was made.

In evaluating these records the total work for each period was computed. The total work done in the initial period was taken as 100 per cent and the other four periods were expressed in percentage of the initial work. The average of the experimental group percentages compared to the control group percentages gave the following results. After the first five-minute rest period, the experimental animals averaged 63.12 per cent as much work as in the initial period while the control animals averaged 59.5 per cent. After the second rest period the experimental animals averaged 25.4 per cent as much as in the initial period, compared to 17.4 per cent as much in control animals. After the third rest period the experimental animals did 10.9 per cent of the initial work while the control animals did 5.4 per cent compared to 2.0 per cent by the control group. A tabulation of these results gives the following:

Animals	% After First Period	% After Second Period	% After Third Period	% After Fourth Period
Experimental	63.1	25.5	10.9	5.1
Control	59.5	17.4	5.4	2.0

Summary

From this work it is concluded that isolated muscles from frogs which had been injected with testosterone, showed approximately 10 per cent greater resistance to fatigue than normal animals.

Male sex hormone increased the capacity of the gastrocnemius muscle of the frog to do approximately 51 per cent more work. The combined records of work and fatigue indicate that male sex hormone reduces the rate of muscle fatigue during repeated periods of work.

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Notes on the Soil Fauna of Cowley County, Kansas.

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and THEODORE H. EATON, JR., Southwestern College, Winfield

Introduction

The activity of soil animals, especially arthropods and annelids, has been studied in forests (1, 6, 9) and agricultural land (4, 5) sufficiently to develop certain principles (8) concerning their relationship to soil fertility. One of these is that the great majority of individuals live in the surface litter and immediately below it, their numbers declining rapidly until they virtually disappear at the lowest horizon of organic matter. Another is that since about 80% of the animals feed on the litter and on organic residues of it (the remainder being predatory), the most important function they perform is to initiate the disintegration of litter into humus, both mechanically and chemically, and it has been shown (10) that the action of bacteria and fungi is aided in large measure by this preliminary working. Buckle (4) found that in England the distribution and numbers of soil animals were more stable in grass than in cultivated land because the vegetative cover remained throughout the year, that as vegetation increased the fauna increased accordingly, and that (5) there is no close correlation between insect species and soil types. Bryson (2, 3) studied the interchange of surface soil and subsoil by burrowing insects at Manhattan, Kansas.

Our observations in Cowley County were made to obtain an estimate of soil arthropod populations, which might be compared with those of New York State (6) and North Carolina (9), in an attempt to shed further light upon some variable features in soil ecology. The work was conducted in the Biology Department of Southwestern College, Winfield, Kansas.

Method and Results

Five local sites were studied, as follows:

Site A. Two miles north of Winfield, adjacent to Timber Creek; a wood lot, predominantly hackberry and elm; soil type Osage Silt Loam (7), a productive, alluvial soil, level and well drained but occasionally subject to overflows.

Site B. An alfalfa field adjoining Site A; same soil type.

Site C. An alfalfa field immediately south of Winfield, near the Walnut River dam; soil type Osage Silty Clay Loam, dif-

fering from the preceding type in greater frequency of inundation and somewhat higher proportion of clay.

Site D. Adjoining Site C, under a scanty growth of elm, hackberry and pecan; same soil type.

Site E. Open grassland 1 mile northeast of Winfield; soil type Crawford Silt Loam (shallow phase), a residual silt loam overlying limestone ledges and escarpments; it is generally level, too shallow to hold adequate moisture, and used mainly for pasturing.

Samples were taken with a metal cyiinder pressed into the soil, covering an area of 0.17 square feet. By slipping a flat metal sheet under it the desired depth of soil could be removed. The block, however, was always too friable to hold together. It was then dried at room temperature for 3 to 4 days, on a coarse screen suspended in a metal funnel, beneath which a beaker with alcohol solution caught the animals. The solution was alcohol 5 parts, water 3, glycerine 1, glacial acetic acid 1. This method is substantially the same as those used by Eaton and Chandler (6) and by Pearse (9). The count of specimens from each sample was made by binocular microscope, in a petri dish placed over a card ruled in squares slightly smaller than the binocular field, to avoid duplication or omission.

To determine the organic content of the soil, two samples were taken from each site, dessicated to constant weight, and then ashed in a muffle furnace until constant weight was obtained. Thus the organic matter content is expressed in Table 1 as percentage of dry weight lost on ashing (2 samples). The faunal count is given as the sum of 3 samples (since the numbers are small), each sample 0.17 square feet in surface area and 1 inch deep.

Table 1

Site	Mites	Spiders	Collembola	Total	Per sq. ft.	% Organic Matter 1	2
A Woodlot	2	6	3	11	22	0.78	0.58
A[1]	4	3	3	10	20	—	—
B Alfalfa Field	7	8	13	28	56	0.70	0.77
C Alfalfa Field	9	12	18	39	78	0.34	0.25
D Open Woodlot	23	14	36	73	146	0.81	1.30
E Open Grassland	3[2]	0	0	3	6	1.19	1.20

1. The second inch below surface.
2. A thick included here.

These counts are so small as to render specific estimates of population per acre almost worthless, but some idea of their magnitude may be taken from the largest count, that of Site D, which comes to 6,301,360 per acre.

Comparison and Interpretation

In the United States quantitative soil fauna studies have dealt

mainly with forest soils, giving results in sharp contrast with those obtained at Winfield. For example, Pearse (9) studied the microfauna of the soil and litter in the Duke Forest, Durham, North Carolina, and presented counts of soil animals per acre in the litter plus the upper 5 inches of soil:

Table 2

Total per acre	123,366,656
Mites	89,602,920
Collembola	28,052,640
Spiders	372,177
Earthworms	90,604

His 4 sites were very different as to soil and vegetation, yet no striking contrast in soil fauna appeared. His actual counts (exclusive of earthworms, snails, nematodes and phalangids) were as follows:

Table 3

Soil	Forest	Litter	Depth 0-2"	Depth 2-5"
Clay	Oak	49,110	13,356	2,387
Clay	Pine	62,557	11,419	2,998
Sand	Oak	60,341	28,116	4,330
Sand	Pine	73,107	24,032	3,022

Eaton and Chandler (6) provided comparable figures for 16 forest sites in central New York state and the Adirondack Mountains. On the basis of humus layer types a condensation of these results is given below (populations per acre, in upper inch only).

Table 4

	Humus Layer Type	Earth-worms	Mites	Collembola	Other Arthropods	Number of Samples
Mull:	Coarse	733,720[1]	28,442,440	10,142,600	6,646,640	12
	Fine	None	133,796,000	38,412,400	5,042,400	2
Mor:	Matted	Trace	167,072,360	88,909,600	14,027,000	13
	Granular and Greasy	None	167,115,520	28,262,480	4,402,320	4

[1]. On basis of 26 samples.

It is evident that in both New York and North Carolina the forest soils support a far greater population of soil animals than do the sites studied at Winfield, Kansas. Since the papers cited in the introduction suggest that soil types have little effect, and since the counts made here fall far below those reported in agricultural land elsewhere, it seemed likely that climatic factors were involved. A detailed comparison of climates at Winfield, Kansas, Durham, North Carolina, Ithaca, New York, and the central Adirondacks revealed no significant correlation of soil population with the following factors:

Average annual precipitation.

Average precipitation, April to September.

Average relative humidity, July, 8. p.m.
Average minimum relative humidity, July.
Average vapor pressure, July.
Average annual snowfall (last at Durham).
Average temperature, June to August.
Length of growing season.
Average percentage of sunshine in summer and winter.
Average wind velocity.

There remains one climatic factor of possible significance, for which precise figures are not available, namely the warm season evaporation (April to September, inclusive). From the Atlas of American Agriculture, 1936, United States Department of Agriculture, an approximate value was obtained:

Winfield	40 inches
Durham	30 inches
Ithaca	25 inches
Adirondacks	25 inches

These differences, coupled with those of vegetation and organic content of the soil, seem to show significant correlation with the soil fauna counts.

The vegetation at Sites A and D was a narrow and scanty belt of trees, such as follows most of the river valleys of eastern Kansas; conditions here cannot be greatly unlike those obtaining before the land was settled. Site E differed in no apparent way from undisturbed prairie. Only Sites B and C were under cultivation, yet the faunal counts do not seem to reflect this.

As to organic content, we have no actual measurements from the papers by Eaton and Chandler, or Pearse, but experience with both cultivated and forest soils in New York state shows that the percentage of organic matter there ranges from about 40 in ordinary coarse mull (such as a lawn) to over 80 in peat and greasy or granular mor. Evidently the contribution of plants to the organic content of the soil is (or originally was, before cultivation) much higher under a general forest cover than it is in prairie and semi-prairie conditions.

Summary

Sample counts of soil fauna in Cowley County, Kansas, gave exceedingly low populations per unit of area in 5 sites studied, the lowest of all being on open prairie land in shallow residual soil. Organic matter content of these soils also appears remarkably low (less than 2% in every case). Comparison with studies made in forest

soils of New York and North Carolina shows that both of these support immensely greater numbers of soil animals. No climatic factor shows direct correlation with these differences, except the warm season evaporation. It is suggested that this, coupled with the somewhat sparse vegetation, may limit both the annual contribution made by plants to the organic content of the soil, and the number of soil animals which can be sustained by it.

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Kansas Plants New to Kansas Herbaria III

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University of Kansas, Lawrence

Since writing the second of this series of papers (Trans. Kans. Acad. of Science, Vol. 50, No. 2. 200-201, 1947) we have found *Cheilanthes lanosa* (Michx.) Wats. in Chautauqua, Elk, Montgomery and Wilson counties.

Leonurus marrubiastrum L. was collected on July 16, 1940, two miles north of Baldwin City, Douglas County. Several large colonies of this species occur in the area known locally as Baldwin woods. Britton and Brown (1913) gave the range of this species as southern Pennsylvania, Delaware and New Jersey.

Humulus japonicus Sieb. and Zucc. was collected on October 4, 1947, growing on the banks of Soldier Creek, one mile north of Topeka, Shawnee County. The long twining vines formed a dense mat on the creek bank. Britton and Brown (1913) list this plant as escaped from cultivation from Connecticut to New Jersey while Rydberg (1932) listed the plant as escaped in Nebraska and Kansas.

Hydrangea arborescens L. was collected on July 16, 1947, six miles east of Baxter Springs, Cherokee County. It was common on a wooded, rocky north hillslope along Shoal Creek. Rydberg (1932) gives the range of this species as New York to Florida, Louisiana and Iowa.

Dodecathon radicatum Greene was collected near Sycamore, Montgomery County on July 12, 1937. It was found growing in a prairie hay meadow. Rydberg (1932) listed Kansas in giving the range of this species.

Tracaulon sagittatum (L.) Small was found on September 10, 1940, growing in a swampy area at the north end of Baldwin Lake located two miles southeast of Baldwin City, Douglas County. Britton and Brown (1913) listed Kansas in the known range of this species.

Ranunculus septentrionalis Poir. was collected on May 1, 1937, four miles south of Mound City, Linn County. It was growing in a low moist woodland. Britton and Brown (1913) included Kansas in giving the range of this species.

Ranunculus micranthus Nutt. was collected on April 20, 1940, in an open rocky woods two miles east of Baxter Springs, Cherokee County. It was present in considerable numbers. Britton and Brown

(1913) gave the range of this species as: Maine to Minnesota, Saskatchewan, Georgia, Arkansas and Colorado.

Solidago wardii Britton was collected on October 6, 1941, six miles north of Havana, Montgomery County. It was growing in abundance on a grassland hillslope. Rydberg (1932) gave the range of this species as Missouri to Arkansas, Texas and west Nebraska.

Oligoneuron riddellii (Frank) Rydberg was collected on August 25, 1934, four miles north of Lyndon, Osage County. It was growing abundantly on a grassland hillslope. Rydberg (1932) gave the range of this species as Ontario to Ohio, Missouri, Iowa and Minnesota.

Vincetoxicum carolinense (Jacq.) Britton was collected on July 16, 1947, six miles east of Baxter Springs, Cherokee County. The plants were located in a thicket on the south slope of a hill in Shermerhorn park. Rydberg (1932) gave the range of this species as Virginia to Iowa, Missouri, Louisiana and South Carolina.

Centaurium calycosum (Buckley) Fernald was collected on July 1, 1947, three miles southwest of Elk City, Montgomery County. A large colony of this species was found on sandy soil in an oak woods. Britton and Brown (1913) gave the range of this plant as Missouri to Texas, Mexico and New Mexico.

Heliotropium indicum L. was collected October 25, 1947, along Spring River east of Crestline. This plant had been credited to Kansas by Rydberg (1932).

Panicum helleri Nash was collected on July 18, 1936, on sandy soil in the Kansas River valley near Lawrence, Douglas County by W. E. Booth. Hitchcock (1935) gave the range of this species as Missouri and Oklahoma to Louisiana and New Mexico.

Panicum scoparium Lam. was collected by W. E. Booth on July 14, 1936, in a sandy woodland along the Kansas River east of Lawrence, Douglas County. Hitchcock (1935) gave the range of this species as Massachusetts to Florida, west through Kentucky to Missouri, Oklahoma and Texas.

Dipsacus sylvestris Huds. was reported for the first time in the state from Miami County by Gates (1946). We have a record of this species collected on July 22, 1947, one mile south of Burlington, Coffey County. A colony of this species was found growing in a pasture and in a roadside ditch.

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THE ANALYSIS AND CHARACTERISTICS OF SELECTED KANSAS SOILS*

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The soils of Kansas are its greatest natural asset. Among the natural resources of Kansas are gas, oil, coal, salt, volcanic ash, clays, lumber, stone, livestock, grasses, etc., but none of these have the potential value to Kansas as do its soils.

The soils of Kansas vary widely in composition and characteristics. The soils of western Kansas have developed under less than 25 inches of annual rainfall while some of the soils of eastern Kansas have developed under more than 40 inches of rainfall. This differential in rainfall has existed for many thousands of years. The effect on soil development of different amounts of rainfall ccan be readily appreciated when it is noted that in regions of low rainfall sub-soil drainage is inadequate to remove highly soluble salts, such as sodium chloride, carbonate and bicarbonate from the soil. On the other hand, in regions of high rainfall sub-soil drainage has washed from the soil not only the highly soluble sodium and potassium salts but the less soluble calcium and magnesium salts as well; even the highly insoluble iron and aluminum ions have been mobilized.

Soils differ not only as a result of the amount of rainfall under which they develop, but from the influence of many other factors, such as the parent material or rocks from which the soils are formed, sub-soil drainage, topography, time, temperature, soil micro-organisms, floods, winds, glaciers, organic matter, air humidity, etc. The humidity in regions of low rainfall is in general much lower than the humidity in regions of high rainfall, thus greatly increasing evaporation. Other things being equal, it is reasonable to expect a soil in a region of 40 inches of rainfall to develop much more than twice as rapidly than a soil in a region of 20 inches of rainfall, since in regions of low humidity evaporation from the surface is greatly increased while sub-soil drainage is proportionately decreased.

It is the purpose of this paper to describe soils in Kansas that have developed under several climatic conditions rather than to describe soil formation processes. The data presented were secured from soils collected to represent several stages of development, as preliminary to certain researches on soil development.

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Samples of the surface (0-6 ins.) and sub-soil (6-20 ins.) of thirteen soils from locations indicated in Figure I have been examined and analyzed. These soil samples were taken in 1943 from plots selected by the agronomy department of Kansas State College as representative of Kansas agricultural conditions. The soils are listed in Table I along with the description of soils regions as given by Fly (3) and rainfall data by Cardwell and Flora (2), calculated to the nearest quarter inch.

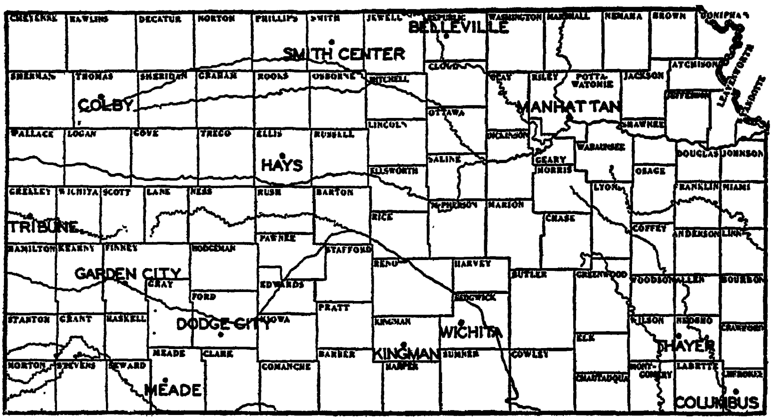


Figure 1. Location of test plots from which soil samples were obtained.

Table I. Location and description of soils studied.

(1) Belleville, Republic County, 26.25 ins. rainfall. Breaks and Loess Bedrock Plains, Central Kansas Rolling Plains Region, Kansas Nebraska Loess and Plains Section.

(2) Colby, Thomas County, 17.75 inches rainfall. Loess Outwash Tablelands. Colorado Kansas Central High Plains Region, Moist Semi-arid Hardlands Section.

(3) Columbus, Cherokee County, 41.75 inches rainfall, Residual Prairies and Interspersed Woodlands Region Southeastern Prairies Section.

(4) Dodge City, Ford County, 19.75 inches rainfall, Loess Outwash Tablelands, Colorado Kansas Central High Plains Region, Dry Sub-humid hardlands section.

(5) Garden City, Finney County, 18.50 inches rainfall, Loess outwash tablelands, Colorado Kansas Central Plains Region, moist semi-arid hardlands section.

(6) Hays, Ellis County, 22.50 inches rainfall, Breaks and Loess Redrock Plains, Central Kansas Rolling Plains Region, Shale and Limestone section.

(7) Kingman, Kingman County, 29.50 inches rainfall, Loess Outwash Tablelands, Great Bend Region, Hardlands Section (Dissected Tablelands).

(8) Manhattan, Riley County, 31 inches rainfall, Residual Prairies and Interspersed Woodlands, Kansas Oklahoma Limestone and Flint Hills Region.

(9) Meade, Meade County, 20.25 inches rainfall. Loess outwash Tablelands, Colorado Kansas Central High Plains Region, Dry Sub-humid Hardlands.

(10) Smith Center, Smith County 22.00 inches rainfall. Breaks and Loess Bedrock Plains, Central Kansas Rolling Plains Region, Shale and Limestone Section.

(11) Thayer, Neosho County 40 inches rainfall. Residual Prairies and Interspersed Woodlands, East Prairies and Interspersed Woodlands Region, Southeastern Prairie Section.

(12) Tribune, Greeley County, 15.75 inches rainfall, Loess Outwash Tablelands, Colorado Kansas Central High Plains Region, Dry Semi-arid Hardlands Section.

(13) Wichita, Sedgwick County, 29.75 inches rainfall. Loess Outwash Tablelands, Great Bend Region, Hardlands Section (Dissected Tablelands).

Among the analyses commonly made on soils which might indicate their potential fertility are mechanical analysis, base exchange capacity, total silica content, total sesquioxide content and the analysis of available nutrient elements. Occasionally thermal analysis

curves are made in an attempt to determine the type of clay in the soil. These analyses have been made on the soils discussed in this paper and the data are presented in the appended tables.

Soil clays are of two types, kaolinitic and montmorillonitic. The kaolinitic clays have a low base exchange capacity and in general are present in soils of a potentially low fertility. Montmorillonitic clays have a high base exchange capacity and their presence in soils is indicative of a high fertility potential.

The mechanical analyses were made on the air dried samples. Determination of particle size was made by treating the soil with 6% hydrogen peroxide to remove organic matter, followed by 0.2N HCl to remove carbonates. The moist soil was then sieved through a 70-mesh screen and the screened material divided into the coarse sand, fine sand, silt and clay separates by sedimentation, aided by the centrifuge. The method followed is that outlined by Piper (6). The size of these separates were respectively 2 mm to 0.2 mm diameter; 0.2 mm to 0.02 mm diameter; 0.02 to 0.002 mm diameter; and less than 0.002 mm diameter. The data obtained from the mechanical analysis are given in Table II.

Table II. Mechanical Analysis of Soils.

Surface soils	Coarse sand %	Fine sand %	Silt %	Clay %	Loss *
Belleville	0.17	70.15	1.67	16.74	11.27
Colby	0.18	58.83	1.60	27.93	11.46
Columbus	6.14	71.88	1.63	12.81	7.54
Dodge City	0.37	67.23	Trace	18.03	14.37
Garden City	2.20	67.52	1.23	17.38	11.67
Hays	0.63	62.11	1.75	22.51	13.00
Kingman	14.15	66.50	0.53	11.29	7.53
Manhattan	0.78	60.20	1.40	28.59	9.03
Meade	0.10	61.41	1.41	23.41	13.67
Smith Center	0.27	70.95	1.19	17.11	10.48
Thayer	1.21	72.38	1.27	14.81	10.33
Tribune	3.85	64.60	1.09	19.66	10.80
Wichita	0.94	60.88	1.14	23.13	13.91
Sub-soils					
Belleville	Trace	63.56	Trace	24.37	12.07
Colby	0.14	66.58	2.71	23.32	7.25
Columbus	9.74	59.52	Trace	19.35	11.39
Dodge City	0.21	63.88	2.57	30.70	2.69
Garden City	2.30	59.27	1.11	18.49	18.83
Hays	0.25	53.78	2.53	33.02	10.42
Kingman	20.61	42.72	Trace	21.33	15.64
Manhattan	0.38	51.82	1.28	35.55	10.97
Meade	1.33	61.15	2.33	21.96	13.23
Smith Center	0.08	63.27	Trace	25.59	11.06
Thayer	1.36	48.50	2.18	27.88	20.08
Tribune	1.24	62.52	1.70	24.25	10.29
Wichita	0.65	59.17	1.64	30.08	8.46

*Moisture, organic matter, carbonates, etc.

A considerable variation in the mechanical composition may be seen readily. The coarse sand varies in the surface soils from 0.17% in the Belleville soil to 14.15% in the Kingman soil, while the clay content varies from 11.29% in the Kingman soil to 28.59% in the

Manhattan soil. The variation of the coarse sand in the sub-soils is even greater. The clay content of the sub-soils is higher than that of the surface soils, but the percentage present varies as much as it does in the surface soil. The minimum clay content of the sub-soils is 18.49% in the Garden City soil and the maximum is 35.55% in the Manhattan soil. The clay fraction of the soil because of its greater reactive surface area retains many of the nutritive elements which are required for plant growth. The clay portion, therefore, may be considered as one factor of great importance in helping to estimate the fertility of a soil.

The base exchange capacity of a soil is a measure of its capacity to hold and retain cationic nutritive elements and is of great importance in helping estimate the fertility of a soil. The base exchange capacity of a soil is also an indicator of the type of clay present. Montmorillonite clays often have a base exchange capacity of around 75 mg. equivalents per 100 grams while the kaolinite clays have a base exchange capacity generally less than 10 mg. equivalents. The base exchange capacity of the thirteen soils, subsoils, and corresponding clay separates is listed in Table III. The base exchange data indicate that the clay separates are more closely related to the montmorillonite clays than they are to the kaolinitic clays. Base exchange capacity was determined by leaching the soil with neutral normal ammonium chloride until the exchange reaction was complete, then washing the axcess ammonium chloride from the soil with water and 85% alcohol. The fixed ammonium was liberated with magnesium oxide and determined by the Kjeldahl method.

Table III. Base exchange capacity of surface soils, sub-soils and clay separates in mg per 100 grams.

	Surface soil	Sub-soil	Surface clay	Sub-clay
Belleville	14.3	17.9	60.0	54.3
Colby	22.1	21.4	57.2	60.0
Columbus	9.3	10.0	54.3	40.0
Dodge City	17.2	20.1	54.3	62.8
Garden City	15.0	16.8	31.5	54.3
Hays	23.6	24.2	48.6	71.4
Kingman	10.0	12.1	51.7	48.6
Manhattan	17.8	22.4	54.3	37.2
Meade	15.0	22.8	48.6	60.0
Smith Center	16.0	17.8	45.7	48.6
Thayer	8.6	19.3	51.4	45.7
Tribune	16.4	22.1	42.7	65.8
Wichita	18.5	21.2	51.4	25.7

Among the major soil constituents are silica and the sesquioxides. The amount of these constituents and their molecular ratios is indicative of the type of soil colloids present and thus an indication of potential soil fertility. A silica/sesquioxide ratio of 2.0 or more is considered as an indication of the montmorillonite beidellite type

of clays, according to Robinson (7). The silica and sesquioxides were determined by A.O.A.C. methods (1).

The analyses and ratios are given in tables IV and V. In every case the ratio is well above 2.0, and in the regions of the state where the rainfall is less than 30 inches the Sio_2/R_2O_3 ratio averages 3.29, while for the regions where the rainfall is 30 inches or more the average ratio is 2.63.. In general as the rainfall increases the silica sesquioxide ratio decreases. This ratio also correlates quite well with the parent material from which the soil is derived. The rainfall and analytical data are given in Table VI arranged in order of increasing rainfall.

Table IV. Silica and sesquioxide content of surface clays.

%SiO_2	%Fe_2O_3	%R_2O_3	%Al_2O_3	SiO_2/R_2O_3*	SiO_2/R_2O_3*
Belleville	44.3	6.75	30.7	23.9	2.32
Colby	44.3	8.82	24.9	16.1	3.47
Columbus	40.2	9.11	30.0	20.9	2.46
Dodge City	48.0	5.39	26.5	21.7	3.32
Garden City	37.3	4.81	19.5	14.7	3.57
Hays	43.0	5.68	23.5	17.8	3.50
Kingman	43.4	6.87	32.2	25.3	2.48
Manhattan	45.5	9.68	34.0	24.3	2.47
Meade	47.8	7.04	26.9	19.9	3.34
Smith Center	43.3	6.66	23.8	17.1	3.44
Thayer	43.2	5.16	54.3	29.1	2.26
Tribune	56.4	6.15	30.3	24.1	3.42
Wichita	47.7	5.78	24.9	19.1	3.50

*Molecular ratio

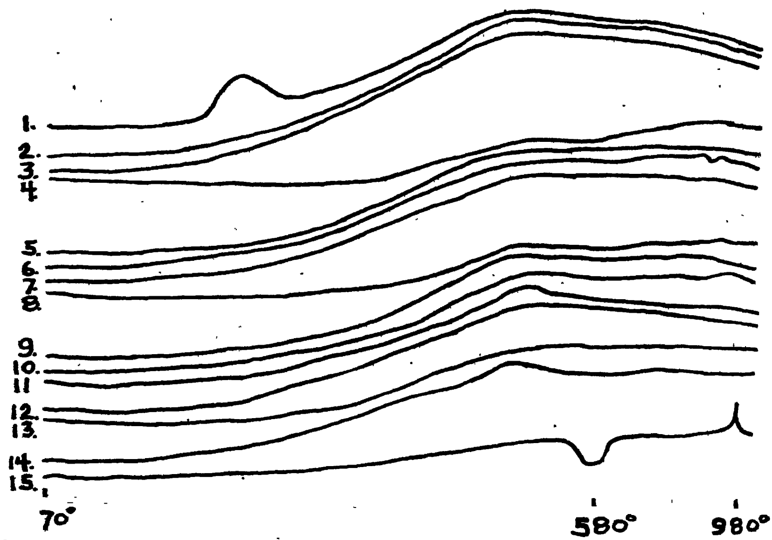
Table V. Silica and sesquioxide content of sub-soil clays.

	%SiO_2	%R_2O_3	%Fe_2O_3	%Al_2O_3	SiO_2/R_2O_3*
Belleville	47.5	27.4	10.0	17.4	3.39
Colby	49.2	28.3	11.7	16.6	3.48
Columbus	44.3	33.4	13.9	19.5	2.66
Dodge City	47.1	28.6	12.4	16.2	3.32
Garden City	45.7	24.8	9.9	14.9	3.66
Hays	48.1	28.5	9.4	19.1	3.26
Kingman	43.2	30.1	9.9	20.2	2.76
Manhattan	43.8	29.0	10.2	18.8	2.93
Meade	46.5	28.0	11.4	16.6	3.32
Smith Center	48.1	31.0	15.5	15.5	3.22
Thayer	41.9	28.8	9.6	19.2	2.82
Tribune	49.2	28.1	11.0	17.1	3.44
Wichita	44.9	29.6	12.0	17.6	3.02

*Molecular ratio

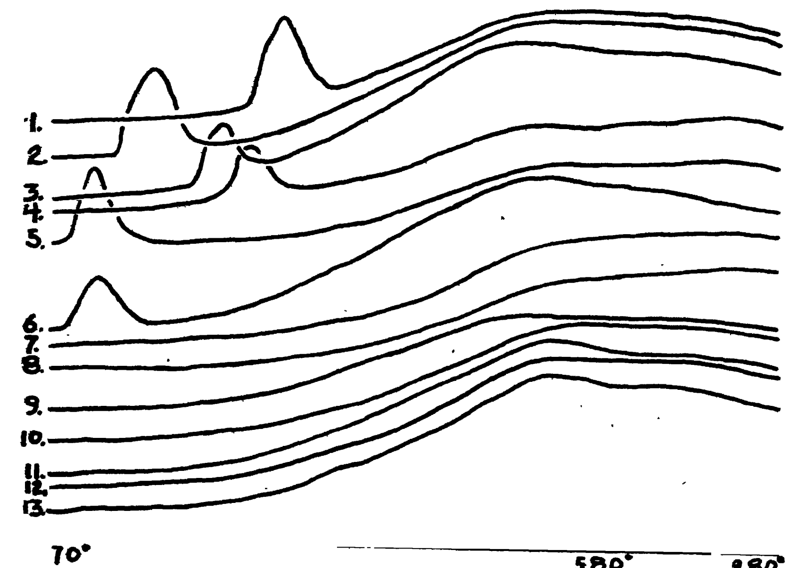
Table VI. Rainfall data. Silica/sesquioxide ratio and parent material of soils and soil clays:

Location	Rainfall	SiO_2/R_2O_3	Description of parent material
Tribune	15.75	3.42	Loess Outwash Tablelands
Colby	17.75	3.47	" " "
Garden City	18.50	3.57	" " "
Dodge City	19.75	3.32	" " "
Meade	20.25	3.34	" " "
Smith Center	22.00	3.44	Breaks & Loess Bedrock Plains
Hays	22.50	3.50	" " " "
Belleville	26.25	2.32	" " " "
Kingman	29.50	2.48	Loess Outwash Tablelands
Wichita	29.75	3.50	" " "
Manhattan	31.00	2.47	Residual Prairies and
Thayer	40.00	2.26	Interspersed Woodlands
Columbus	41.75	2.46	" " "



GRAPH 1. Thermal Curves of Clays from Surface Soils.

1. Belleville
2. Columbus
3. Kingman
4. Colby
5. Dodge City
6. Garden City
7. Hays
8. Manhattan
9. Meade
10. Smith Center
11. Thayer
12. Tribune
13. Wichita
14. Bentonite
15. Kaolin



GRAPH II. Thermal Curves of Clays from Sub-soils.

1. Garden City
2. Colby
3. Meade
4. Thayer
5. Manhattan
6. Belleville
7. Smith Center
8. Kingman
9. Tribune
10. Wichita
11. Hays
12. Dodge City
13. Colby

Identification of the clay mineral of the soil is a difficult task; in fact positive identification is very difficult, but among the methods that give the greatest help in identification is thermal analysis. Therefore, thermal curves were run on the clay separates in order to collect additional information on their identity; these curves are given in graphs I and II along with typical curves of kaolin and bentonite.

The thermal curves presented were obtained according to methods outlined by Grim (4). The unknown mineral was heated at a rate of about 5° per minute in a special electric furnace. A double junction thermocouple was inserted both in the unknown mineral and in a thermally stable mineral and temperature differentials recorded by a reflecting galvanometer and photographic paper. Kaolin decomposes at 580° losing water which is indicated as an endothermic reaction in graph II. The alumina resulting from the decomposition of kaolin alters its form at 980° which is indicated by an exothermic reaction. The irregularities at approximately 200° in six sub-soils and one surface soil are probably due to undecomposed organic matter and are worthy of further investigation. The curves obtained indicate that the clays of the Kansas soils are all of the same general type and are probably of the montmorillonite-beidellite type rather than of the kaolinitic type. This conclusion is supported by the silica/sesquioxide ratio and the base exchange capacity.

To evaluate better the potential fertility of these soils, extracts were made with Morgan's universal soil solvent (5), which, theoretically, dissolves the elements available for plant growth. The analyses of such extracts are presented in Table VII and VIII. The actual analyses of the soil extracts were made by spectographic and colorimetric methods. Manganese, iron and copper were determined spectographically as outlined by Schrenk and King (8). Potassium, calcium, phosphorus, nitrogen and magnesium were determined colorimetrically according to the methods of Wolf (9). The pH determinations were made on a 1-10 soil water ratio with a glass electrode.

The available nutrient content of the soils show a distinct correlation between the rainfall and the potential fertility of the soil. The potassium content of the soils decrease as the rainfall increases. The average available potassium content of the five surface soils receiving the least rainfall was 259 parts per million of the soil, while the corresponding potassium figure for the five soils receiving the most rainfall was 118 parts per million. The corresponding values for calcium are 3256 and 848 and for phosphorus 55.1 and 29.4.

Table VII. Available potassium, calcium, phosphorus, and nitrogen content and pH of Kansas soil. Parts per million of original soil.

Location	Depth	pH	K*	Ca	P	N
Tribune	0-6	6.60	230	5800	67.0	108
	6-20	8.20	203	6000	41.0	92
Colby	0-6	6.40	293	3060	63.6	117
	6-20	7.98	314	4400	46.4	—
Garden City	0-6	6.50	157	3120	48.1	71
	6-20	8.15	140	12800	60.1	86
Meade	0-6	6.40	385	1040	45.7	131
	6-20	6.50	169	5600	44.2	90
Dodge City	0-6	6.50	232	3260	51.0	148
	6-20	6.75	94	6000	42.4	57
Hays	0-6	6.40	211	3000	48.3	89
	6-20	6.45	154	4400	58.7	55
Smith Center	0-6	6.57	240	3000	35.6	55
	6-20	6.50	156	2900	38.6	93
Kingman	0-6	6.05	83	1140	18.9	101
	6-20	6.20	57	1960	33.8	143
Belleville	0-6	6.20	141	1600	33.6	110
	6-20	6.40	91	3120	26.7	80
Wichita	0-6	6.25	300	2900	43.6	144
	6-20	6.20	97	3100	32.2	141
Manhattan	0-6	6.05	107	2080	25.0	109
	6-20	6.15	109	3120	23.9	79
Thayer	0-6	6.10	22	1600	25.2	94
	6-20	5.98	25	1880	17.9	66
Columbus	0-6	6.10	21	1060	19.8	74
	6-20	5.95	27	1000	12.9	95

*Data in parts per million.

Table VIII. Available magnesium, magnanese, iron, and copper in Kansas soil.

Location	Depth	Mg*	Mn	Fe	Cu
Tribune	0-6	200	30	32	2.6
	6-20	184	30	52	3.2
Colby	0-6	136	50	30	2.8
	6-20	—	14	18	2.6
Garden City	0-6	288	20	40	3.2
	6-20	280	20	36	3.2
Meade	0-6	40	104	32	2.8
	6-20	200	36	32	2.6
Dodge City	0-6	72	66	28	2.6
	6-20	248	44	78	4.2
Hays	0-6	256	44	32	2.4
	6-20	144	10	20	2.6
Smith Center	0-6	184	46	40	2.8
	6-20	416	28	30	2.6
Kingman	0-6	48	64	46	2.8
	6-20	40	26	30	2.4
Belleville	0-6	72	78	30	3.4
	6-20	208	16	24	2.8
Wichita	0-6	248	30	40	2.8
	6-20	264	50	46	2.8
Manhattan	0-6	88	76	22	2.8
	6-20	320	36	30	2.4
Thayer	0-6	80	84	48	3.6
	6-20	96	26	56	3.2
Columbus	0-6	56	20	24	2.2
	6-20	284	34	68	3.8

*Data in parts per million

Summary

Thirteen representative Kansas soils were sampled and analyzed, and the data thus obtained reveal marked differences in the mineral and chemical composition, which in many cases can be correlated with rainfall. The same type of clay mineral prevails in all of the soils while the silica/sesquioxide molecular ratio decreases as the

rainfall increases. The available nutritive elements, especially potassium, calcium, and phosphorus decrease as rainfall increases. Other data collected show great variations but fail to reveal any correlation with rainfall, parent material, or other obvious characteristics. The type of clay mineral in these soils is of the beidellite, montmorillonite group.

Considering silicia/ratio, available potasium, calcium, and phosphorus the fertility of the soils is approximately in inverse ratio to the amount of rainfall.

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Mountain Sheep From the State of Washington in the Collection of the University of Kansas

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On August 27, 1826, over 130 years ago, Dr. David Douglas met an Indian near the site of the present town of The Dalles, Oregon, while traveling from Walla Walla to Fort Vancouver, Washington. Douglas obtained from the Indian a mountain sheep that had been killed near Mount Adams, Washington. This specimen provided the basis for his description of *Ovis californianus* (*Ovis canadensis californiana*). At the time (1826), mountain sheep ranged over much of the mountains and desert regions of California, Oregon, Washington, and British Columbia. At present the subspecies is nearly extinct in California, extinct or nearly so in Oregon, and reduced to perhaps one band in Washington, in the vicinity of Bauerman Ridge and Mount Chopaka. A few small bands are still present in British Columbia (see Cowan, American Midland Naturalist, 24: 557-558. 1940).

In 1889 the display collection of big game animals at the Museum of Natural History, University of Kansas, was being built, and Professor L. L. Dyche made an expedition to Mount Chopaka, Okanogan County, Washington, to collect specimens of mountain sheep. According to the Museum catalogue no less than 54 specimens of *O. c. californiana* were brought back to the Museum by the expedition. Of these 54, according to the catalogue, 5 are without skulls, 8 specimens have the skulls mounted within the skins, and 4 are on deposit elsewhere. A total of 37 skulls, of which 33 are males and 4 are females, have been studied by us. This is the largest series of North American bighorns from any one locality (Mount Chopaka) known to us to exist in any museum (see also Cowan, *op. cit.*, 509). Much of the flesh of most of these skulls was cut away in the field, but only recently have the skulls been more completely cleaned in order to check accurately the age-variation and individual variation.

Material and Methods

Of the 37 skulls here reported upon, number 1786 (10-year old ram) seems to be a "pick-up". It lacks the lower jaw, end of rostrum, maxillary teeth, and the bones are somewhat weathered.

The horns are in good condition. Number 1805 (5-year old ewe) has the right, posterior, ventral portion of the cranium missing, apparently shot away by a bullet. Other than these, the specimens have suffered little damage in the field.

Some damage has occurred between the time the sheep were killed and their skulls "roughed out", and the final preparation of the skulls, 56 years later. This is especially true of the incisiform teeth which, in almost all skulls have shattered and splintered. Since the lower jaws were wrapped in muslin, many of the fragments of the incisors have been recovered. The shattering has probably resulted from temperature changes, but the molariform teeth are not shattered. Many of the mandibles have developed small, longitudinal cracks. One horn-sheath of number 1806 (5-year old ewe) and both horn-sheaths of number 1792 (ram, judged to be 10 years or more of age) are lost. These may be among the miscellaneous, unlabelled, sheep horns in the museum but positive association with the correct skulls at this date seems impossible. The lower jaws of numbers 1805 (5-year old ewe) and 1820 (6-year old ewe) were not found. With the exceptions noted above, the series is in splendid condition.

Because our series apparently represents the largest existing collection of mountain sheep from a single locality, and because it represents a subspecies that may soon entirely vanish, a detailed study to determine age and individual variation seems advisable. Noteworthy, also, are the large number of aberrations in dentition and shape of cranial bones. The information offered here is supplemental to that of Cowan (*op. cit.*, 510-518). The same cranial measurements have been taken as used by Cowan and explained by him (*op. cit.*, 524-525). Age has been determined by growth rings on the horns and for older animals is probably accurate to plus or minus one year, and in younger ones accurate as to year.

Horns

Details of the growth of horns are given by Cowan (*op. cit.*, 512) and are not repeated here. Measurements of horns given in table 1 are in inches rather than millimeters because sportsmen who record measurements ordinarily in inches may be interested in the findings of our study. Little accuracy can be claimed because the tips of the horns may be blunted, much worn, splintered or intact. The measurements were taken to the end of the horn, regardless of its condition. The diameter of the horn was not taken at the extreme

base, where the sheath is thin and commonly flared-out, but just above this point.

Variation in the size and shape of the horns is enormous. Some are closely-coiled while others are widely sweeping; some diverge at a wide angle, others diverge at a narrow angle; some are massive, some are relatively slim; some taper evenly, and some taper irregularly, having uniform diameters for considerable distances; some have the tips intact; some are bluntly-rounded; and some are irregularly shattered terminally. Indeed, no two pairs of horns are even closely similar.

Table 1.—Measurements, in inches, of horns of rams and ewes from Mt. Chopaka, Washington

Catalog No.	Age, in years	Length, right horn	Length, left horn	Distance between tips	Circumference, right horn	Circumference, left horn	Catalog No.	Age, in years	Length, right horn	Length, left horn	Distance between tips	Circumference, right horn	Circumference, left horn
MALES													
1804	3	17¾	18¼	18¾	11	11	1793	7	28	27¾	21¾	13	13½
1794	3	21½	21	17¾	11¼	11¼	1795	7	28¾	28	19¾	13¾	13¾
1801	4	21	19¾	18½	11¾	11¼	1790	7	29	31	20	12½	12½
1784	5	23	24	19½	12½	11½	1782	7	30	30¼	20½	13	13¼
1800	5	27	26	18¼	12¼	12½	1778	8	30	29	19	14	14
1789	5	28	28	19¾	12½	12½	1797	8	30	29½	16½	13	13¼
1799	6	27	29¾	21½	13	13	1777	8	31	31	21	13½	13½
1780	6	28	27¾	19¼	13	13	1776	9	29	31½	21	13	13
1783	6	28½	28	19¾	13½	13½	1775	9	30½	32¾	24¼	14	14
1785	6	29½	26½	19½	13¼	13¼	1773	9	31½	32¼	20¼	13¾	14
1798	6	30	30½	19	12½	12½	1771	10	30	32	25¼	13¾	13¾
1772	6	30½	30½	18½	13¼	13½	1770	10	31	31	21¾	13	13
1779	6	31¼	30	23¼	13	12½	1786	10	31	32	....	13¼	13¾
1781	6	31¼	30½	20½	13½	13¾	1774	10	31½	31	20	14½	14½
1803	7	20¾	21½	17¾	13½	14	1769	10	32	31¾	20¼	14	14¼
1788	7	27¼	29½	18¼	13½	13½	1796	11	32¼	33½	17½	12¾	12¾
FEMALES													
1806	5	....	8½	....	....	4½	1802	5	10	10	11	5¾	5¾
1805	5	9¾	9½	11½	5¼	5¼	1820	6	10½	11	13½	5½	5½

In this variation, however, specimen number 1803 (a 7-year old ram) stands out at extreme. The horns are heavy basally but are short, little curved and abruptly tapering. The basal diameter is slightly larger than normal but the length along the outside curve is only about two-thirds of the normal length.

Several specimens have the horns chipped on the anterior face, not far from the skull. This, we suppose, results from fighting. An extreme example is number 1770 (10-year old ram). In it a triangular slab has been torn from the anterior face of the right horn, 75 mm. from the skull. The scar measures 140 mm. in length, 80 mm. in greatest width and 15 mm. in extreme depth.

Cranium

In the series from Mount Chopaka, 9 individuals less than six years of age are available. In these there is indication that many

parts of the cranium grow most rapidly until the age of 6 years, or slightly less, and after this age, less rapidly. Certain measurements (see table 2) such as basilar length, orbital width, zygomatic width, and maxillary width tend to show this. The palate remains

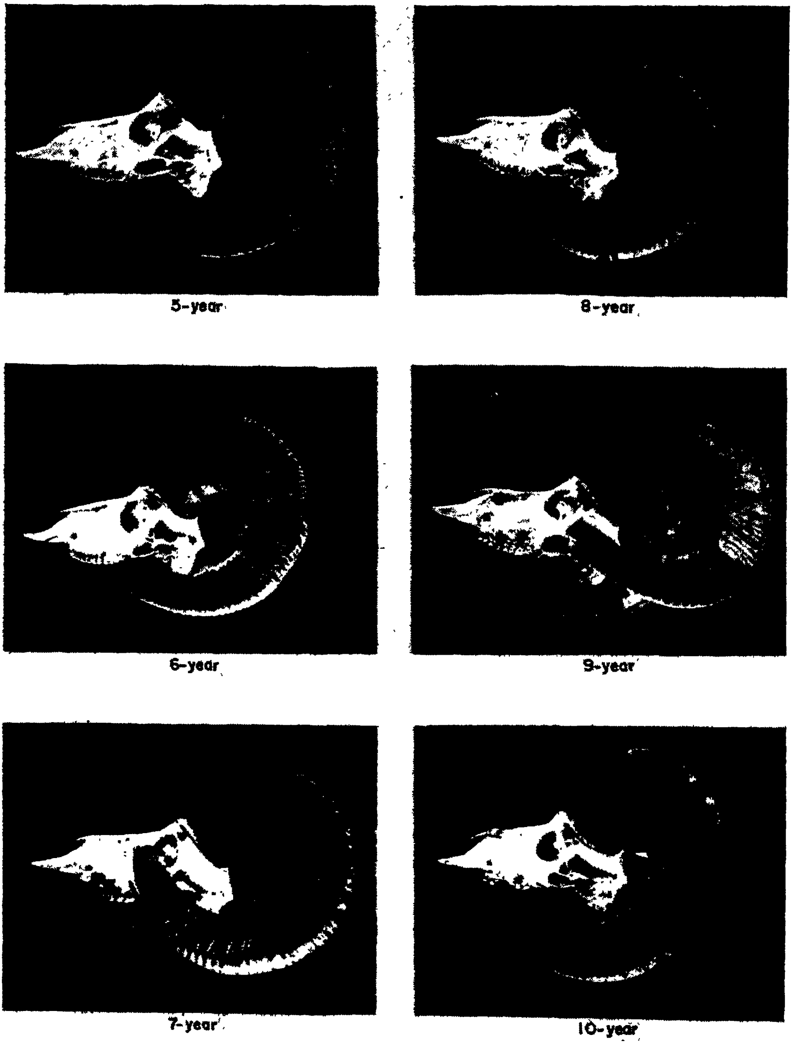

Fig 1. Laterial views of the skulls of male bighorns, Ovis canadensis californiana, from Mount Chopaka, Washington. The specimens are all in the Museum of Natural History, University of Kansas, and have the following catalogue numbers: 5 year old, 1789; 6, 1781; 7, 1790; 8, 1778; 9, 1771; 10, 1774.

about the same in width from 3 years to 11 years, judging from our measurements of the breadth of the palate across P^2 and M^3. The palate increases in length more rapidly up to the sixth year, and less rapidly after that time, but does continue to increase in length. As one might expect, length of molar tooth row, above and below, remains fairly constant.

Cranial Aberrations

In number 1800 (5-year old ram) the basioccipital region is

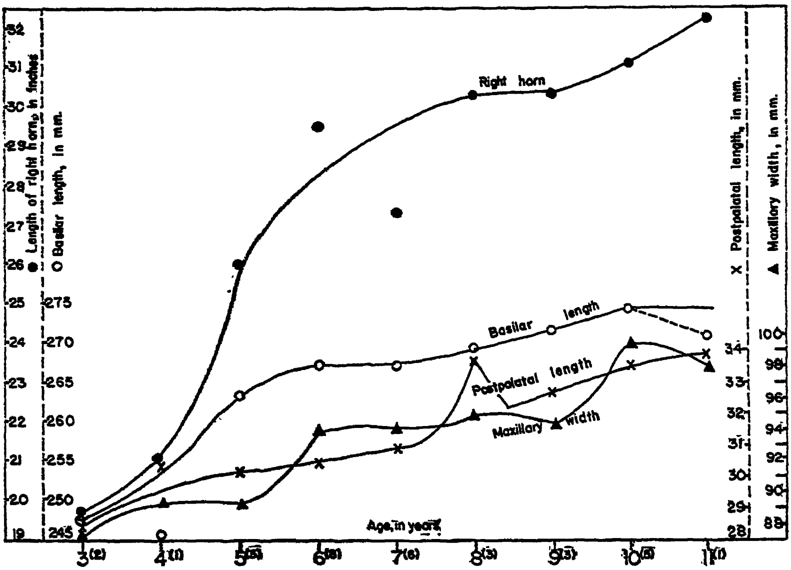

Fig. 2. Changes in parts of the skull and horn with increasing age. Numbers in parentheses along the horizontal scale represent number of animals measured for that age group.

deflected to the left about three degrees from the plane of the rostrum. Number 1806 (5-year old ewe) has an aberrant bone on the left side of the palate. The bone is roughly circular, surrounded by what seems to be a suture, and is harder and more nearly smooth than the rest of the palate.

The lateral (lower) nasal sutures are commonly more or less open and roughened. Extreme cases are numbers 1772 (6-year old ram) and 1770 (10-year old ram). In the former the junctions of the lacrimal, nasal and frontal sutures are open in the form of rough pits, 11 by 2 mm. on the left side and 10 by 2 mm. on the right side. In number 1770 the right premaxilla does not meet the nasal by three mm. The corresponding suture on the left side is unusually denticulate.

The nasal bones themselves are commonly thickened medially and, if irregularly so, give a "humped" appearance. If the thickening is more even the nasals appear riged. This is well shown in number 1793 (7-year old ram).

Injury to the nasal region of the skull seems common. The thickening just mentioned may result from injuries. The left nasal of number 1784 (5-year old ram) has a longitudinal, medial fracture 45 mm. long. In three old rams, injuries to the rostrum and bone resulted in malformed skulls.

Number 1773 (9-year old ram) has the rostrum deflected to the right. The right premaxilla is fractured. The left premaxilla is not fractured but is bent dorsally, and to the right past the median line of the skull. Both maxillae are cracked at the posterior edge of the incisive foramina.

Number 1774 (10-year old ram) had the anterior 50 mm. of the nasals shattered. The injury has healed and the bone is roughened and thickened. The anterior edges of the nasals are rough and unequal, with sharp, spinelike processes.

Ram number 1771, also 10 years of age, received an injury of the left nasal approximately 60 mm. from the anterior edge and five mm. from the median line, where there is a rough pit about 10 mm. long, five mm. wide, and five mm. deep. The bone has been eroded in places and there are exostoses on it in other places, causing an extremely rough surface and some distortion which is reflected in the suture separating the nasal from the premaxilla and maxilla.

Dentition

Incisiform teeth.—In the normal adult mountain sheep the incisiform teeth (lower first to third incisors and canine) are spatulate with disk-like worn surfaces on the posterior side of each tooth. The direction of wear appears to be almost vertical. The largest teeth in the series are the first incisors. Each succeeding tooth posteriorly is smaller. The teeth overlap each other, the medial edge of the second incisor being slightly posterior to and extending inwards (medially) past the outer side of the first incisor. The outer edge of the second incisor overlaps the inner edge of the third incisor and, similarly, the outer edge of the third incisor overlaps the inner edge of the canine.

The incisiform teeth of most of the skulls in our series are more or less shattered. Most, however, are normal as may be ascertained from the examination of the remaining teeth and fragments of the broken ones. Several abnormalities were detected, however.

The commonest abnormality is the excessive narrowing of the incisiform teeth, which produces a fanglike tooth rather than a spatulate one, and the narrow worn surface is at an angle of 45 degrees with the jaw, rather than perpendicular to it. Specimens showing this condition have catalogue numbers 1770, 1769, 1777, and 1796. In the last one the narrowness is especially marked and, in addition, the first and second incisors on the right side were lost in life and the remaining teeth on each side lean inwards at an angle of 25 degrees and close the gap which otherwise would exist. The root of the right canine is exposed. These specimens are males from eight to 10 years of age.

The first and second incisors of a 3-year old ram (number 1804) are larger than usual, while the third incisor and the canine are very small, though of normal spatulate shape. The width of the crown of the second incisor is 10.6 mm. The width of the crown of the third incisor is exaactly half (5.3 mm.) that of the second.

In a 10-year old ram, number 1769, the posterior incisiform teeth overlap the anterior teeth whereas the reverse is true in other specimens.

Upper canines.—The occurrence of vestigal upper canines (or possibly caniform first premolars) in North American mountain sheep has been reported on by Benson (American Midland Naturalist, 30: 786, 1943), who found them to be present in two of 53 specimens and in one of approximately 250 others examined by him. In our series of 37 skulls, six possess canines and a seventh (2-year old ram, number 1777) has small alveoli. Numbers 1805 (5-year old ewe), 1781 (6-year old ram), and 1793 (7-year old ram) possess both right and left canines that are exposed ventrally. Numbers 1804 (3-year old ram) and 1776 (9-year old ram) have the right canine exposed, the left alveolus present and the left canines present. Number 1784 (5-year old ram) has the right canine exposed; neither the canine nor an alveolus is present on the left side.

Upper premolars.—The upper premolars in our series of mountain sheep are highly variable because of aberrations, disease, injuries and wear.

The most unusual condition noted was rounded teeth. In specimens with rounded teeth, one or more upper premolars are, when viewed from the occlusal face, almost perfectly circular in cross section, rather than quadrate. Examples are numbers 1800, 1802 and 1806 (two 5-year old ewes and a 5-year old ram). In 1800, both second and third premolars, left and right, are rounded. In

1802 only the left second premolar is rounded; the right is quadrate. In 1806 the right second premolar is rounded and the left, though quadrate, is unusually narrow anteroposteriorly.

In number 1776 (9-year old ram) the second premolar on the right side is deflected posteriorly, its anterior surface making a 60 degree angle with the palate.

Effects of disease were noted in the premolars of two young rams. Number 1784 (5-year old) has the roots of the second premolars exposed anteriorly by erosion of the bone. Number 1799 (6-year old) has what appears to be a dental cavity in the fourth left premolar.

Loss or distortion of premolars commonly results from injuries. In number 1769 (10-year old ram) the entire right premolar series is offset posteriorly to partly close the gap resulting from the loss of the right first molar. In number 1774 (10-year old ram) the fourth, right premolar was lost in life. The third premolar and first molar have "floated" into the alveolus of the missing tooth and the third premolar has become narrowed anteroposteriorly, perhaps through unusual wear. The second premolar has elongated and curved backwards, its anterior surface forming a 60 degree angle with the palate.

In number 1770 (10-year old ram) the left third premolar is missing. In number 1771 (10-year old ram) the left second premolar is missing; the third is worn smooth and broken. The left third and fourth premolars of number 1790 (7-year old ram) have been lost; a few shattered and diseased fragments of the roots remain in the alveoli. In number 1775 (9-year old ram) the right second premolar is shattered and partly missing. In number 1773 (9-year old ram) the left second and third premolars are shattered but intact.

The upper premolars are remarkable for uneven wear. In some moderately-aged animals (six to eight years) the premolar series shows much wear while some older animals have upper premolars much less worn.

Lower premolars.—The lower premolar series is only slightly less variable than the upper, and the variation seen apparently results from the same causes.

The most unusual condition noted is in number 1793 (7-year old ram). The left fourth premolar has become constricted near the root and the tooth has bent lingually. The crown is displaced two mm. lingually. The alveolus is shallow.

A tendency to reduction and loss of the second premolar is noticeable in the series, although it is difficult to ascertain, in some

older specimens whether the tooth was lost in life and the alveolus closed over, or if, instead, the tooth was never present.

Rudimentary teeth are seen in numbers 1789 (5-year old ram) and 1806 (5-year old ewe). In number 1789 the right second premolar measures only five and five-tenths by four and five-tenths mm. and is only two and five-tenth mm. high—hardly half as large as the tooth of normal size. In life it could have projected little if at all above the gum. The right second premolar of number 1806 is but a small spine, two mm. wide, one and five-tenths mm. long and three mm. high. It slants posteriorly at a 30 degree angle. The left second premolar of this same sheep is absent. A tiny pit, less than one mm. in diameter, may represent the alveolus. Number 1802 (5-year old ewe) has neither right nor left second premolars, nor is there any indication of alveoli. Number 1774 (10-year old ram) lacks the right second premolar. The alveolus, if ever present, has completely closed.

The left second premolar of number 1784 (6-year old ram) was broken off near the base and the alveolus has nearly closed. It now measures only five by three mm. The left third premolar of number 1770 (10-year old ram) is missing; the alveolus measures only three by three mm. The left second and left third premolars of number 1769 (10-year old ram) have been lost and the fourth premolar has bent backward 20 degrees.

Irregular wear is seen in the lower as well as the upper premolar series. The right second premolars of number 1777 (8-year old ram) and 1803 (7-year old ram) are unusual in that they possess high, spikelike cusps; the height is 12 mm. from the alveolus. In some younger sheep these teeth are much worn. Other irregularities are of lesser magnitude.

Molars.—Relatively few abnormalities were noted in the upper and lower molar series, save those resulting from wear and extreme age. In the old animals, teeth are missing, worn unevenly and shattered. The conditions noted do not seem in most instances worthy of special description. In number 1769 (10-year old ram) the anterolabial side of the right, first, upper molar is spikelike, extending 20 mm. above the alveolus and 12 mm. above the occlusal surface. The anterior edge of the right, lower, second molar is similarly high and spikelike. The left, first, lower molar of this sheep is missing, save for a bit of diseased root. The mandible about the alveolus has eroded away, leaving the ramus only 22 mm. deep. The opposite ramus, showing no sign of disease, is 28 mm. deep at the corresponding place.

Number 1790 (7-year old ram) is notable for the early loss of teeth. In the upper jaw, the right first and second molars, left third and fourth premolars and first molar are missing. The lower molars and remaining upper molars are much worn.

Table 2.—Cranial measurements, in mm., of 3, 4, 5, 6, 7, 8, 9, 10, and 11 year old rams from Mt. Chopaka, Washington

Catalogue number	Age, in years	Basilar length	Greatest length of nasals	Width of nasals	Orbital width	Zygomatic width	Maxillary width	Mastoid width	Palatal breadth at M^3	Palatal breadth at Pm^2	Postpalatal width	Palatal length	Upper molariform series	Lower molariform series	Prealveolar length	Postdental length	Width of basioccipital	Width of premaxillae
1794	3	254	100.1	46.9	109.4	119.6	84.1	84.4	54.0	30.2	28.1	78.9	88.9	91.0	80.8	74.9	28.4	27.1
1804	3	241	103.5	49.3	114.8	122.7	90.4	91.4	55.1	32.8	28.7	94.7	90.7	(87.1)	78.7	72.2	29.3	29.8
Av. of 3's		247.5	101.8	48.1	112.1	121.0	87.3	87.9	54.6	31.5	28.4	86.8	89.8	89.1	79.8	73.6	28.9	28.5
1801		245	104.0	44.3	112.8	120.7	89.9	87.1	57.0	29.9	30.5	88.7	83.0	84.1	75.0	76.8	27.9	27.3
1789	5	268	118.1	51.4	118.8	122.8	91.4	87.9	55.0	33.3	30.5	96.6	88.4	90.0	87.3	80.5	29.9	31.5
1784	5	265	118.4	47.5	113.3	121.9	87.6	89.0	53.7	28.2	30.5	93.8	90.1	90.0	82.6	80.9	25.9	29.4
1800	5	257	107.4	43.6	116.5	122.2	89.2	89.5	55.8	29.0	29.3	87.9	87.4	88.1	78.6	79.1	28.6	29.4
Av. of 5's		263.3	114.6	47.5	116.2	122.3	89.4	88.8	54.8	30.2	30.1	92.8	88.6	89.4	82.8	80.2	28.1	30.1
1780	6	273	....	....	126.2	130.3	95.0	96.6	56.7	33.0	30.0	99.3	88.9	87.2	88.1	85.0	31.5	31.8
1781	6	272	....	....	128.9	131.1	98.6	97.7	57.3	35.7	31.5	101.1	91.9	91.3	85.7	81.8	33.2	32.6
1798	6	271	....	....	123.2	122.8	93.1	90.0	55.7	34.2	30.9	106.4	88.0	87.3	84.6	83.5	31.5	35.3
1779	6	266	....	....	121.4	124.1	94.9	95.3	54.8	29.3	30.6	100.1	86.3	93.0	82.1	81.3	33.6	32.3
1799	6	266	....	....	122.5	125.4	91.4	89.7	52.6	32.3	30.1	93.9	87.5	90.1	83.2	81.4	31.0	32.3
1772	6	266	....	....	121.9	127.3	93.6	88.0	54.1	32.0	29.9	94.1	90.9	96.0	80.3	82.9	30.3	30.1
1783	6	262	....	....	122.4	124.9	94.2	88.5	55.7	33.7	31.1	96.6	88.9	92.3	83.4	73.2	29.2	33.8
1785	6	262	....	....	125.0	124.0	90.8	93.3	54.2	31.0	30.6	98.9	98.5	89.0	81.1	80.0	30.9	31.3
Av. of 6's		267.3	....	....	123.9	126.2	94.0	92.4	55.1	32.7	30.6	98.8	80.1	90.8	83.6	81.1	31.4	32.4
1782	7	275	....	....	122.8	125.1	90.1	91.3	54.6	31.1	31.3	96.9	87.5	90.2	89.6	84.6	28.9	32.4
1793	7	272	....	....	126.0	127.0	93.6	93.0	54.3	32.0	31.9	101.9	86.0	90.0	84.0	......	30.0	31.4
1788	7	272	....	....	129.0	128.1	95.6	95.6	56.0	37.5	30.1	101.2	84.9	87.1	89.6	88.4	28.4	33.4
1790	7	267	....	....	122.0	120.8	93.2	92.1	51.8	29.6	31.5	97.7	87.5	89.1	83.3	82.3	31.1	30.2
1795	7	266	....	....	126.3	127.7	96.5	92.9	57.5	35.6	31.5	99.9	84.9	89.6	84.6	85.3	31.5	34.1
1803	7	251	....	....	115.9	122.2	95.1	86.1	58.8	35.4	29.1	90.0	83.5	82.9	82.4	82.0	29.1	32.8
Av. of 7's		267.2	....	....	123.7	125.2	94.0	81.8	55.5	33.5	30.9	97.9	85.7	88.2	85.6	84.5	29.8	32.4
1777	8	275	....	....	124.4	130.2	93.5	92.8	52.5	31.8	33.7	92.5	91.7	89.7	84.4	84.0	32.8	31.8
1778	8	272	....	....	123.7	128.3	96.9	94.3	58.3	32.7	35.2	100.4	91.6	93.2	81.4	85.4	34.4	......
1797	8	261	....	....	128.2	128.5	94.6	90.7	56.7	29.8	32.1	91.2	88.4	93.9	81.1	77.9	30.8	33.1
Av. of 8's		269.3	....	....	125.4	129.0	95.0	92.6	55.8	31.4	33.7	94.7	90.6	92.3	82.3	82.4	32.7	32.5
1775	9	273	....	....	131.3	133.0	100.0	97.9	57.6	34.6	34.1	104.5	88.2	89.1	85.9	85.3	31.7	32.7
1776	9	270	....	....	122.9	126.1	89.3	92.2	54.2	32.4	29.4	101.1	93.0	94.9	84.1	82.6	29.8	30.7
1773	9	....	....	....	127.3	126.4	93.4	91.3	54.0	32.7	34.2	91.1	86.6	91.1	......	88.8	32.4	......
Av. of 9's		271.5	....	....	127.2	128.5	94.2	93.8	55.3	33.2	32.6	98.9	89.3	91.7	85.0	85.6	31.3	31.7
1771	10	270	....	....	129.2	131.5	98.4	98.9	57.7	39.6	31.8	103.8	87.9	90.4	84.9	84.2	30.5	34.6
1770	10	275	....	....	130.0	127.3	98.3	97.9	56.3	40.2	33.6	99.6	79.8	82.0	90.3	95.6	32.8	34.7
1769	10	270	....	....	129.1	128.4	99.2	93.9	58.9	38.5	33.3	97.6	82.6	90.0	89.6	85.8	30.6	33.1
1774	10	283	....	....	126.7	....	96.4	99.3	53.0	35.1	35.2	105.8	89.1	91.1	90.5	93.3	33.1	36.9
1786	10	....	....	....	....	....	105.2	94.5	......	31.3	33.0	....	85.0	......	......	88.9	30.7	......
Av. of 10's		274.5	....	....	128.8	129.1	99.5	96.9	55.2	36.9	33.4	101.7	84.9	88.4	88.8	89.6	31.5	34.8
1796	11	271	....	....	125.9	130.6	98.0	93.1	58.5	35.7	33.9	100.7	86.4	87.5	90.2	85.0	32.8	33.0

SUMMARY

1. Thirty-seven skulls of *Ovis canadensis californiana* obtained in 1889 from one locality have been critically examined. This race of mountain sheep is now nearing extinction.

2. Variation in the size and shape of the horns is extreme.

The variations affect the nature of the coiling, the uniformity of tapering and the angle of divergence of the horns.

3. Growth in the skull is most rapid in animals less than six years of age. In postnatal development, the facial area of the skull grows more than the cranium.

4. Cranial aberrations are rather common. Most of these affect the rostral area of the skull, and seem to be the result of injuries.

5. Abnormalities of the incisiform teeth are relatively few and those which do occur are of slight degree.

6. Six of our 37 specimens have upper canines in at least one side of the jaw.

7. The upper premolar series shows numerous aberrations, including: rounded teeth; deflection of teeth; loss or distortion due to injury or disease; absence of teeth; and uneven wear.

8. The lower premolar series shows but slightly fewer aberrations than the upper premolar series. Two rudimentary teeth were present in the lower premolars.

9. The molar teeth above and below show relatively few abnormalities. Those noted seem to be the result of age and uneven wear.

Report of the Delegate to the Academy Conference

FRANK C. GATES, Academy Delegate

The Academy conference for 1947 met at 4 p.m., December 27, 1947, in the Sherman Hotel, Chicago, with Dr. Howard H. Michaud, of Purdue, as chairman and Dr. Austin Middleton, of Louisville, secretary. About 60 were present. Special consideration was given to the relationship between academies, scientists in general and the general public. The need of scientists as a body to present their place in the scheme of modern life was emphasized over and over. Likewise the need to educate the general public in a program for mutual benefit was stressed. At the conference dinner Dr. K. Lark-Horovitz, the generel secretary of the American Association for the Advancement of Science, presented an informative, stimulating paper on a survey of the present situation in science and science teaching, together with ways in which state academies in cooperation with junior academies, universities, and colleges have a chance to be the main factor in maintaining scholarship standards and in providing proper cooperation between scholarship agencies and science service. The contribution of the academy will primarily be as follows:

"The academies can contribute widely to the dissemination of scientific information by arranging for inter-science meetings on a state and regional scale; by sponsoring exchange of professors between colleges and the larger universities, and by attracting professional personnel from industry, medicine, and agriculture into the academy.

"By arranging statewide programs, both of technical presentations as well as popular lectures, the academy can promote adult education in science and also science education for the student who has just finished high school and does not go to college.

"For this purpose the state academy must solicit: (a) the participation of the representative of the learned societies in the state; (b) cooperate with the many amateur societies in the country."

Among the special papers given, the following should be mentioned. Dr. Marchand found that among Kentucky high school and junior colleges, there were 87 biology teachers who had had no biology courses, 16 chemistry teachers without chemistry, 16 physics teachers without physics, 10 general science teachers who had not attended college, and 110 who had had no science education, altho

they may have attended college. They considered that 14 is the average top educational age, but find that 32 per cent of the students cannot go above that.

Dr. Shapley stated that scholarships for science scholars were an important part of the pilot plan in connection with national defense. In addition to the two national talent searches, ten states now have a state talent search. Virginia, Alabama and Tennessee were mentioned particularly. In Virginia, 50 students are recognized each year, of whom 15 are considered state winners. In Alabama, commercial interests have furnished funds for the establishment of five "General William Crawford Gorgas Scholarships" with a total value of $9500 and administered by the Alabama Academy, as reported by James L. Kassner.

John Thompson of the Wisconsin Academy reported duties of senior academy members towards junior academy members as follows: "Attend their meetings, act as judges, and give financial aid as necessary."

H. A. Webb, of Tennessee, reported on the efforts to get more subject-matter training into teacher development, now notoriously low.

G. A. Prescott, of the Michigan Academy, reported on possible ways in which the senior state academy could render greater service in each state.

Possibility of the academy's functioning in states or regions in a similar manner to that of the American Association in the whole nation was discussed and the duty of scientists to make every effort to bring science to the people was emphasized.

THE EIGHTIETH ANNUAL MEETING

The eightieth annual meeting of the Kansas Academy of Science was held at the Kansas State Teachers College at Pittsburg, Kansas, on April 29, 30, May 1, 1948, with Dr. J. C. Peterson, of Kansas State College, presiding. The Kansas Entomological Society, an affiliated society of the Academy, held its 24th annual meeting at Manhattan, Kansas, on March 20, 1948. The mathematical groups held their meeting this year at Atchison. Part of the geologists met with the American Association of Petroleum Geologists at Denver, Colorado.

From the Senior Academy 136 registered, together with 87 visitors, and an attendance of 125 was reported from the Junior Academy, a total of 348. Thursday evening the Southeast Kansas Section of the American Chemical Society met with additional academy members at a dinner in the College cafeteria. In lieu of the lecture on magnesium not given by H. A. Ellis, of the Dow Chemical Company, an account of sickness, four local impromptu speakers were drafted, three from the Spencer Chemical Company and one from the Atlas Powder Company at Carthage, Missouri. Harry Ziessig discussed the use of punch cards in filing cases for quick reference work; Lawrence Branifs of the Atlas Company talked on non-military explosives; J. G. McArthur told of new corrosion test methods; and Henry Woodward, Jr., discussed cosmetics and perfumes. Following the talks, given in the Music Hall Auditorium, a general reception was held in the lobby of the Music Hall, under the direction of Mrs. O. W. Chapman and girls from the chemistry department of the College.

Sectional meetings were held Friday morning and afternoon and Saturday morning. Reports from the section chairmen will be found in Table 1.

Table 1

Name of section or organization	Chairman for 1948	Number papers on program	Number attending	Chairman for 1949
Botany	T. M. Sperry	20	90	R. L. McGregor
Chemistry	John Davis	12	70	W. G. Schrenk
Geology (at Pittsburg)	W. H. Schoewe*	4	30	Frank Byrne
Junior Academy Science	Ralph Rogers	....	150	Ralph Rogers
Kansas Entomological Soc. (at Manhattan)	Fred D. Butcher	31	68	Louis Kuitert
Physics	W. H. Matthews	7	45	R. H. McFarland
Psychology	Paul Murphy	19	65	Dr. A. C. Voth
Science Teachers	Margaret Parker	2	60	P. S. Albright
Zoology	Claude Leist	14	65	Otto Tiemeier

*Substituting for Dr. Byrne.

On Friday afternoon was given the highlight of the meeting, a symposium on the topic "Some Recent Scientific Developments with

Social Implications," participated in by J. S. Hughes, Professor of Chemistry, Kansas State College, *Physical Science.*

L. D. Wooster, President, Fort Hays, Kansas State College, *Biological Science.*

Joseph W. Nagge, Professor of Psychology, Kansas State Teachers College, Emporia, *Psychology.*

Edwin R. Walker, Chairman, General Education Division, Oklahoma A. and M., Stillwater, Okla., *Social Science.*

followed by spirited questions and discusions by speakers and audience. On account of sickness, Dr. Nagge's paper was read by Dr. W. H. Gray.

Friday evening, immediately after the fine banquet in the College cafeteria, President Peterson gave his retiring address "Some Factors and Pitfalls in the Application of Knowledge." President-elect Albertson acted as toastmaster. An address of welcome was given by President Rees H. Hughes of the college, 136 pere present.

At 8:15, Friday evening in the Music Hall Auditorium occurred the Public address: "Present Knowledge of the Interior of the Earth." by James B. Macelwane, S. J., dean of the Institute of Geophysical Technology, St. Louis University, St. Louis, Missouri.

The following officers were elected for 1948-1949:

President, Dr. F. W. Albertson, Ft. Hays Kansas State College;
President-elect, Dr. Paul G. Murphy, Kansas State Teachers College at Pittsburg;
Vice President, Dr. P. S. Albright, Wichita University;
Secretary, Dr. A. M. Guhl, Kansas State College;
Treasurer, Mr. Standlee V. Dalton, Ft. Hays Kansas State College;
Librarian, Dr. D. J. Ameel, Kansas State College;
Additional Members of the Executive Council:
- Dr. A. B. Leonard, U. of Kansas;
- Mr. A. C. Carpenter, Ottawa;
- Dr. John C. Frye, U. of Kansas;

Associate Editors for the Transactions: (3 year terms)
- (Physics), Dr. A. B. Cardwell, Kansas State College (Term expires 1951),
- (Zoology), Dr. Mary T. Harman, Kansas State College (Term expires 1951).

The next annual meeting will be held at Manhattan in the spring of 1949.

The official program as revised is given below.

Frank C. Gates, *Secretary.*

THURSDAY, APRIL 29, 1948

4:00 p. m. Registration, Science Hall, First Floor.
4:00 p. m. Executive Council Meeting, Room 110, Russ Hall.
6:15 p. m. Dinner, College Cafeteria, Southeast Kansas Section of the American Chemical Society.
7:45 p. m. Music Hall Auditorium. Program arranged by the Southeast Kansas Section of the American Chemical Society and the Kansas Academy of Science.
Reception following the lecture for members and visitors.

FRIDAY, APRIL 30

8:00 a. m. Registration, Science Hall, First floor.
8:00 a. m. And thruout the meeting. Exhibits and demonstrations.
Rooms 108, 112, 112a, Science Hall.
9:00-11:00 a.m. Section Programs.
Botany, Science Hall, Room 211.
Chemistry, Science Hall, Room 203.
Physics, Mechanic Arts, Room 205.
Psychology, Russ Hall, Room 213.
Zoology, Industrial Arts, Room 2.
9:00- 4:00 p.m. Junior Academy of Science, Science Hall, Room 210.
11:15-12:00 First General Business Meeting. Music Hall Auditorium.
12:00 m. Lunch and meeting of Committees.
1:00-2:30 p.m. Section Programs, Continued:
Physical Science Teachers, Science Hall, Room 203.

Other Sections Continued from Morning

2:30-4:30 p.m. Symposium. Music Hall Auditorium.
Some Recent Scientific Developments with Social Implications.
J. S. Hughes, Prof. Chemistry, K. S. C. Physical Science.
L. D. Wooster, President F. H. K. S. C. Biological Science.
Joseph W. Nagge, Prof. Psychology, K.S.T.C., Emporia. Psychology.
Edwin R. Walker, Chairman, General Education, Oklahoma A. & M., Stillwater, Okla. Social Science.
6:15 p. m. Banquet, College Cafeteria.
Toastmaster—Pres.-elect F. W. Albertson, Hays.
Address of Welcome—Pres. Rees H. Hughes, Pittsburg.
Presidential Address—Some Factors and Pitfalls in the Application of Knowledge. Pres. John C. Peterson, Manhattan.
8:15 p. m. Public Address: "Present knowledge of the interior of the earth." by James B. Macelwane, S. J., Dean of the Institute of Geophysical Technology, St. Louis University, St. Louis, Missouri. Music Hall Auditorium.

SATURDAY, MAY 1

9:00-10:30 a.m. Section Programs.
General Section, including papers in Geology and Botany. Russ Hall, Room 110.
Other Sections Continued from Friday.
10:30-11:45 a.m. Final Business Meeting.
Reports of Committees.
Election of Officers.
Noon Luncheon Meeting of the 1948 Executive Council.
1:00-3:30 p.m. Field Trip under the leadership of Nelson F. Rogers of U.S. F.S., Central Forest Experiment Station at Pittsburg to current coal stripping operations, old and recent forest plantings on strip pit spoil banks, geological strata revealed on strip pit high walls, fossil beds of both plant and animal forms, where individual collecting may be done, native prairie vegetation of the "Cherokee strip" state park development on strip pit spoil banks, and the state quail farm, and the party cconsisted of 27 persons in 8 cars.

BOTANY

Chairman, T. M. Sperry

FRIDAY, APRIL 30—9:00-11:00 a.m., 1-2:30 p.m.

1. Kansas Algae II. Two new species of Xanthophyceae and a new record. R. H. Thompson, U. of K. Lantern. 10 min.
2. Bryophytes of Kansas and Missouri. L. J. Gier, William Jewell College, Liberty, Mo. Lantern. 10 min.
3. Botanical notes for 1947. Frank U. G. Agrelius, K. S. T. C., Emporia. 5 min.
4. Kansas plants new to Kansas Herbaria III. W. H. Horr and R. L. McGregor, U. of K. 5 min.
5. Kansas Botanical Notes, 1947. Frank C. Gates, K. S. T. C., 5 min.
6. Beach Pool Development in a Northern Michigan Lake. Frank C. Gates, K. S. C. Lantern. 10 min.
7. First Year Invasion of Plants on an exposed Lake Bed. R. L. McGregor, U. of K. 5 min.
8. Kansas Stripland Reclamation—Where More Research is Needed. Fred P. Eshbaugh, U. S. D. A., Soil Conservation Service, Manhattan. Lantern. 10 min.
9. Growth of Black Walnut on Certain Strip Mine Banks in Southeast Kansas. Nelson F. Rogers, U. S. F. S., Central States Forest Experiment Station, Pittsburg. 10 min.
10. Morphology in Relation to Control in the Water Hyacinth. Wm. T. Penfound, U. of Oklahoma. Latern. 10 min.
11. Kansas Prytopathological Notes: 1947. E. D. Hansing and C. O. Johnston, K. S. C. Latern. 10 min.
12. Variation in Pathogenicity of Ophiobolus graminis Saccardo. C. M. Slagg and Hurley Fellows, K. S. C. Lantern. 10 min.
13. Soil Fungi of the Muscotah Bog. Frank H. Emerson, U. of K. 5 min.
14. Top and Root Growth of Buffalo and Blue Gamma Grass in relation to frequency and height of clipping. F. W. Albertson, F. H. K. S. C Latern. 10 min.
15. Studies of seasonal height-weight production of stems and leaves in native prairie grasses. John L. Launchbaugh, Jr., F. H. K. S. C. Lantern. 10 min.
16. Effects of different intensities of Utilization upon the Underground parts of short grasses in west central Kansas. Farrel A. Branson, F. H. K. S. C. Lantern. 10 min.
17. Monthly yields, percent utilization and nutritive value of grasses on Dakota sandstone soils. Byron O. Blair. F. H. K. S. C. Lantern. 10 min.
18. Some comparative studies on yields of forage and beef from moderately and heavily grazed pastures in Ness county, Kansas. Andrew Riegel, F. H. K. S. C. Lantern. 10 min.
19. Study of viable seeds in surface soils from various habitats in Ellis county, Kansas. Robert D. Lippert, Norton. 10 min.
20. The effect of defoliation on the functions of Red Winter Wheat. Edwin C. Miller, G. A. Gries, Wm. A. Lunsford, ex-K. S. C. Presented by John C. Frazier, K. S. C. 10 min.

CHEMISTRY

Chairman, John A. Davis

FRIDAY, APRIL 30—9-11 a.m.

1. A New Method for the Study of Isothermal Ternary Systems. Max Anderson and Robert Taft, Sr., U. of K. 10 min.
2. Complex Ion Properties from Solubility Data. W. J. Argersinger, Jr., and C. A. Reynolds, U. of K. 13 min.
3. Diffusion Coefficients of Dyes in Gelatin Gels. Orland W. Kolling and P. Daniel Schultz, Friends University. 8 min.
4. Bromination of Phenol in Various Solvents. Sam H. Johnson and Ray Q. Brewster, U. of K. Lantern. 10 min.

5. A New Method for the Determination of Caffeine in Coffee. Jerome B. Thompson and Henry Werner, U. of K. 10 min.
6. The State of Vitamin A in the Blood of the Dog and the Cat. Roy Coleman and D. B. Parrish, K. S. C. 10 min.
7. The Relation of Introductory Science Courses at Bethel College to both General and Specialized Education. L. C. Kreider, Bethel College. 10 min.
8. Statistical Quality Control in College Analytical Laboratories. O. W. Chapman, K. S. T. C., Pittsburg. Lantern. 15 min.
9. Comparison of the Methods for Determination of Soil Calcium. Harold S. Choguill and Byron O. Blair, Fort Hays K. S. C. Lantern. 7 min.
10. The Composition of Several Representative Kansas Soils. A. T. Perkins and W. G. Schrenk, K. S. C. Lantern. 20 min.
11. Synthesis of 2, 4 Dichlorophenoxy Acetic Acid from Urea. Joe L. Hermanson, John Sheets and John Thorson. Bethany College. (Title.)
12. Application of the Electronic Theory to some Simple Organic Reactions. IV. Calvin A. Vanderwerf, U. of K. (Title).
13. Solvent Effects of Salts Upon Potassium Bromide Dissolved in Acetic Acid—Ernest Griswold, U. of K.

ENTOMOLOGY

The Kansas Entomological Society held its 24th annual meeting at Kansas State College, Manhattan, March 20, 1948. Officers: Fred D. Butcher, president; L. Hepner, vice-president; D. A. Wilbur, secretary-treasurer. Attendance, 68, papers on the program, 31. New officers for the coming year: L. Hepner, president; Louis Kuitert, vice-president; D. A. Wilbur, secretary-treasurer; and P. B. Lawson, editor.

GEOLOGY

Chairman, Wm. H. Schoewe

Saturday, May 1—9-10:30 a.m.

1. The Geodetic Datum of North America. Walter H. Schoewe, U. of K. Lawrence. Lantern. 10 min.
2. Proper Mixtures of Ellis County, (Kansas) Soils for Adobe Construction. H. A. Zinszer and B. W. Read. F. H. K. S. C. 10 min.
3. Chalk Beds. George M. Robertson, F. H. K. S. C. 10 min.
4. Comparing the Records on Two Very Different Methods of Flood Control, Stream Management, and Water Use. B. Ashton Keith, Inst. of Sciences, Kansas City. 4 min.

JUNIOR ACADEMY OF SCIENCE OF KANSAS

Chairman, Ralph Rogers

Local Chairman, Ruth Moon

Presiding Officers, Lyle Davis, Wichita East, President, Betty Kersey, Yates Center, Secretary.

FRIDAY, APRIL 30

Registration 9 a. m. Science Hall Lobby.
Exhibits, Science Hall, Room 108.
Program, 10:30 Science Hall, Room 210.

THE GENERAL SCIENCE CLUB
INDEPENDENCE HIGH SCHOOL
INDEPENDENCE, KANSAS

Announcer—Martin Wagner
Heisler Tube—Bernard Schmidt
"Rudy" The Trained Gopher—Ralph Bretches
Jacob's Ladder—Allen Mason
The Jumping Ring—Bill Pittman

Explosions—Jim Gillmore
Assisted by—Martin Wagner
A—Carbide
B—Dust
C—Molecular
A Solenoid Engine—Larry Farrell
The Citizen's Radio Band—Gilbert Hammond
Our Exhibit Case—Edward Krone
Sponsor—W. L. Gillmore

WICHITA HIGH SCHOOL EAST

Bob Pope—Home-made Substitute for a Kepp Apparatus for the Preparation of Gases
Dan McKinley—An Automatic Timer for Jet Cars
David Mohilner—Method of Measuring the pH
Burton Scott—Forms of Light, Electricity and their Uses
Richard Keys—A Spectrograph
Don Fry—A Periodic Chart
Junior Wahl—Jet Car Racing

PITTSBURG SCIENCE CLUB

Talks: Development of Plastics—Harrison Kaah
Radio-Active Isotopes—Mitzi Angwin
Famous Women in the Field of Science—Anna Catherine Lindsay.
A Study of Interesting Nesting of Birds—Wanda Tosser
The Opportunity for Women in the Field of Veterinary Medicine—Janice Jacques.
Demonstrations: Some Helpful Hints on Mounting of Display Work—Betty Pacconi and Peggy Jackson
Liesegang Rings—Jim Hamilton and Norma Johnson
Exhibits: A Study and Collection of Some Common Spring Flowers—Norma Jean Barbero
School Photography—Max Stacy, Richard Slinkman, Don Caldwell, Don Clugston.

LAWRENCE SCIENCE CLUB

Talk: Fossil Plants From the Lone Star Area—David Horr
Exhibit Phosphorescent Sky Maps—Jack Fletcher
Exhibit Mineral and Rock Collection—Dean Hamill, Joe Beatty, Gary Dumas
Exhibit Rebuilding Dioramas Picturing Prehistoric Life—Dorothy Pickel, Joyce Kimber, Marjory Pickens, Carol Jo Paxton, Ellen Sellers
Exhibit Manufacture of Soap—George Kreye
Exhibit Invertebrate Fossils From Lecompton Area—Jim Koch, D. Hamill
Talk Black Light—Jim Koch

CHANUTE SCIENCE CLUB

Talk: The Necessity of Animal Experimentation for Progress in Medicine—Kay Kelley.

MANHATTAN SCIENCE CLUB

Demonstration: Oxidation With Ozone—Warren Roepke, Carlisle Pickett
Talks: Aircraft Design—Glen Ferlemann, Jack Nelson
The Home Dark Room—Richard Hodgson
Genetics—Earl Herrick.

Wichita will present a program. The Wichita group is from East High. Exhibits have been prepared by the above schools as well as by the College High, Pittsburg.

WINNERS

Talks:
First—Janice Jacques, Pittsburg High
Second—Harrison Kash, Pittsburg
Third—Kay Kelley, Chanute High

Demonstrations:
First—Bob Pope, Wichita East
Second—Norma Barbero and Joan Trumbule, Pittsburg
Third—Glen Ferleman and Jack Nelson, Manhattan

Individual Exhibits:
First—John Wahl, Wichita East
Second—John Hamilton, Pittsburg
Third—Jim Brown, Pittsburg High

Group Exhibit:
First—College High, Pittsburg
Second—Pittsburg High
Third—Lawrence Junior High

General Program
First—Wichita East
Second—Pittsburg High
Third—Independence

Best Individual—Burton Scott, Wichita East.
Burton is to be the A. A. A. S. member for the next year.
Officers Elected for 1948-49.
President—Janice Jacques, Pittsburg High School
Secretary—David Horr, Lawrence Junior High
Chairman—Ralph Rogers, Manhattan High School.

PHYSICAL SCIENCE TEACHERS SECTION

Margaret Parker, Chairman

FRIDAY, APRIL 30—1-2:30 p.m.

SYMPOSIUM ON ATOMIC STRUCTURE

1. Atomic Structure and Periodic Functions—
   (a) Electron arrangement
   (b) Relation of chemical properties to electron arrangement
   (c) Proposed periodic charts, Margaret Parker, K. S. T. C Pittsburg. 30 min.
2. Nuclear Structures and Atomic Energy—
   (a) Nuclear particles
   (b) Stability of particles and atoms
   (c) Atomic artillery
   (d) Results of bombardments
   (e) Atomic fission
   (f) Atomic energy, L. W. Seagondollar, U. of K. 40 min

PHYSICS

Chairman, Wm. H. Matthews

FRIDAY, APRIL 30—9-11 a.m.

1. A problem in sensitized fluorescence. R. H. McFarland, K. S. C., Manhattan
2. Microwave Phenomena. Robert E. Gladfelter and Dr. S. W. Cram, Emporia
3. A Home-Made Collimator for Testing Binoculars. R. F. Miller, Baker University.
4. Construction of the University of Kansas 3-Mev Electrostatic Generator. L. W. Seagondollar, U. of K.
5. Existence of Low Lying Nuclear Energy Levels. C. S. Clay, K. S. C., Manhattan

6. A Comprehensive Course in Physical Science. Wm. H. Matthews, K. S. T. C., Pittsburg
7. Recent Investigations in the Far Infrared Beyond 25 Mu. David M. Gates, Denver University (By title).

PSYCHOLOGY

Chairman, Paul G. Murphy

FRIDAY, APRIL 30—9-11 a.m. and 1-2:30 p.m.

1. Neurotic Tendencies in College Students. J. A. Glaze, K. S. T. C., Pittsburg, 10 min.
2. The Professional Knowledge of Secondary School Counselors. Helen K. Schuyler, K. S. T. C., Pittsburg. 10 min.
3. The Work of the Personal Counselor in the Veterans Administration in Kansas. Hollis D. Kemper, Veterans Administration, Wichita. 10 min.
4. The Relationship of Certain Descriptive Factors of Hypnotizability. Gerald A. Ehrenreich, Menninger Foundation, Topeka. 10 min.
5. The Religious Implications of Jung's Psychology. Eugene E. Dawson, K. S. T. C., Pittsburg. 10 min.
6. The Effect of Vocational Occupation on Woman's Femininity. Sister Anne Cawley, Mount St. Scholastica College, Atchison. 10 min.
7. Thematic Apperception Test Diagnosis of a Nazi War Criminal. Anonymous Post-Mortem Evaluation by a Group of Graduate Clinical Psychology Students: Problems of Inter-Judge Consistency. Rudolf Ekstein and Walter Kass, Menninger Foundation, Topeka. 10 min.
8. The Effect of Varied Difficulties of Conditioned Response Upon the Optimal Interval Between Conditioned and Unconditioned Stimuli. R. R. Lamoreaux, K. S. T. C., Pittsburg. 8 min.
9. Sensory Integration and Ego Functioning: A Hypothesis. George S. Klein, Menninger Foundation, Topeka. 10 min.
10. The "Schematizing Process" In Sensory Functioning: Weight Discrimination. George S. Klein, Menninger Foundation and H. J. Schlesinger, Winter Veterans Hospital. Topeka. 10 min.
11. Some Problems Involved in Establishing the Significance of Atypical Distributions. Edwina A. Cowan, Consulting Psychologist, Wichita, and Bentley Barnbas, President, Associated Personel Technicians, Wichita. 10 min.
12. A Progress Report on Some Experiments with Cola Beverages. N. H. Pronko and J. W. Bowles, Jr., U. of Wichita. 10 min.
13. Color Discrimination in Children. D. L. Synolds and N. H. Pronko, U. of Wichita. 10 min.
14. Use and Abuse of the Diagnostic Test "Index." Walter Kass, Menninger Foundation, Topeka. 10 min.
15. Personality Development in Monozygotic Twins Differing in Physique from Adventitious Factors. Roger G. Baker, U. of K. 10 min.
16. An Examination of the Physically Disabled in Relation to the Normal with Respect to Humor. Leola S. and Milton W. Horowitz, U. of K. 10 min.
17. Menstruation and Industrial Efficiency. Anthony J. Smith, U. of K., Lawrence. 10 min.
18 The Needs of Children and the Curriculum. Herbert F. Wright, U. of K. 10 min.
19. Validity and Reliability of Personality Tests in the Selection and Placement of Personnel. B. Barnabas, Associated Personnel Technicians, Wichita, Kansas.

Business Meeting of the Kansas Psychological Association.

ZOOLOGY

Chairman, Claude Leist

FRIDAY, APRIL 30—9-11 a.m.

1. Some Influences of Sex Hormones on the Blood Pattern. E. H. Herrick and Edwin Martin, K. S. C. Lantern. 10 min.
2. Coyote Studies: A Preliminary Report on Reproduction. H. T. Gier, K. S. C. Lantern. 10 min.
3. The Bearing of Fossil Evidence on the Problem of Vertebrate Origin. George M. Robertson, Ft. Hays K. S. C. Latern. 10 min.
4. An Insight into the Embryonic Development of Trematodes. D. J. Ameel, K. S. C. Lantern. 10 min.
5. The Air Sacs of Birds: A Comparative Study. H. T. Gier, K. S. C. Lantern. 10 min.
6. The Reappearance of Fishes in the Cow Creeks of Crawford County, Kansas. Edgar M. Leonard, K. S. T. C., Pittsburg. Lantern. 5 min.
7. Functional Anatomy and Systematic Position of the Catfishes. Theodore H. Eaton, Southwestern College. 15 min.
8. A Preliminary Check List of the Fishes of Cherokee County, Kansas, and Notes on their Distribution. R. Edward Stevens, K. S. T. C., Pittsburg. Presented by C. Leist for Author. Lantern. 5 min.
9. Sight Records of Rare Birds in Eastern Kansas. Ivan L. Boyd, Baker U. 5 min.
10. Some Buoyancy Factors in Surface-Feeding and Diving Ducks. Rev. Eugene W. Dehner, St. Benedict's College. Lantern. 15 min.
11. Use of 2x2 Transparencies in the Laboratory. L. J. Gier, William Jewell College. Lantern. 10 min.
12. Sight Records on Bird Migration in North Central Kansas for Ten Years. J. M. Porter, M.D., Concordia, Kansas. (By title.)
13. Ecological Comparisons of Three Genera of Moles. Theo. H. Scheffer, Puyallup, Wash. (By title.)
14. The Occurrence of a Ring Neck Dove in Missouri. L. J. Gier, William Jewell College. Lantern. 4 min.

CONSTITUTION AND BY-LAWS
As Amended and Revised Up to May 1, 1948

Constitution*

SECTION 1. This association shall be called the Kansas Academy of Science.

SEC. 2. The objects of this Academy shall be to increase and diffuse knowledge in various departments of science.

SEC. 3. The membership of this Academy shall consist of three classes: annual, life and honorary.

(1) Annual members may be elected at any time by the committee on membership, which shall consist of the secretary and other members appointed, annually, by the president. Annual members shall pay annual dues of one dollar, but the secretary and treasurer shall be exempt from the payment of dues during the years of their service.

(2) Any person who shall have paid seventy-five dollars in annual dues, or equivalent due to legal exemption, or in one sum, or in any combination, may be elected to life membership, free of assessment, upon recommendation by the membership committee and a majority vote of those attending the annual business meeting of the Academy.

(3) Honorary members may be elected because of special prominence in science by being nominated by at least two Academy members in good standing, the nomination being submitted in writing to the membership committee for approval and recommendation to the Academy at its annual meeting. A two-thirds vote of all members present at the annual business meeting shall constitute election. Honorary members pay no dues.

SEC. 4. The officers of this Academy shall be elected at the annual meeting, and shall consist of a president, the president-elect, a vice-president, a secretary and a treasurer, who shall perform the duties usually pertaining to their respective offices. The president, the secretary and the treasurer shall constitute the executive committee. The secretary shall be in charge of all the books, collections and material property belonging to the Academy except those provided hereinafter in the Constitution and By-Laws.

SEC. 5. Unless otherwise directed by the Academy, the annual meeting shall be held at such time and place as the executive com-

*The changes made in the Constitution and By-Laws as published above. can be determined by comparison with the last previously published copies. (See these *Transactions*, vol. 43, p. 7 (1940); vol. 47, p. 115 (1944-45).

mittee shall designate. Other meetings may be called at the discretion of the executive committee.

SEC. 6. This Constitution may be altered or amended at any annual meeting by a vote of three-fourths of attending members of at least one year's standing. No question of amendment shall be decided at the business meeting of its presentation.

SEC. 7. This Academy shall have an executive council, consisting of the president, the president-elect, the vice-president, the secretary, the treasurer, the retiring president, the editor, the managing editor, and three other members to be nominated by the nominating committee and elected in the same manner as the other officers. This council shall have general oversight of the Academy not otherwise given by this Constitution to officers or committees.

SEC. 8. The official publication of this academy shall be known as the *Transactions of the Kansas Academy of Science* and authority is hereby granted its editor and managing editor to publish said *Transactions*. The official publication shall be issued annually, quarterly or at such other intervals as shall be decided upon by the editorial board and executive council.

SEC. 9. The editorial board named in section 8 shall consist of an editor, an assistant editor, a managing editor, and five associate editors. The members of this board shall be selected to include representatives of the major fields of science and, with the exception of the assistant editor, shall be elected in the same manner as other officers of the Academy but for a period of three years.

The editor shall be the officer of the editorial board directly responsible to the Academy for the publication and conduct of the *Transactions;* he shall be the chairman and executive officer of the editorial board and at his discretion may appoint an assistant editor, whose term of office shall be coincident with that of the editor, and whose duty it shall be to assist the editor in his duties. The editor, together with other members of the editorial board shall form the editorial policy of the *Transactions* including the selection, revision and editing of papers submitted to the *Transactions*.

The managing editor, working with the editor, shall be responsible for the business management of the *Transactions,* including the making of publication contracts, the ordering of cuts and supplies, the distribution of the *Transactions,* the securing of advertising (if desirable), and the securing of publicity and of increased circulation for the *Transactions*.

SEC. 10. The Academy shall have a librarian to be elected yearly at the annual meeting.

SEC. 11. The chairman of the Junior Academy of Science shall be elected for a period of three years. He shall be a member of the Executive Council.

By-Laws

I. At the beginning of each annual session there shall be held a brief business meeting for announcements and appointment of committees. For the main business meeting, held later in the session, the following order is suggested:

1. Reports of officers.
2. Reports of standing committees.
3. Unfinished business.
4. New business.
5. Reports of special committees.
6. Election of officers.
7. Election of life and honorary members.

II. The president shall deliver a public address at one of the general sessions of the annual meeting.

III. No annual meeting shall be held without a notice of the same having been published in the papers of the state at least fifteen days previously and the membership informed of the date and place of the meeting by the secretary.

IV. No bill against the Academy shall be paid by the treasurer without an order signed by the secretary.

V. Names of members more than one year in arrears in dues shall be dropped from the membership list.

VI. Ten per cent of the active membership shall constitute a quorum for the transaction of business. Section meetings may not be scheduled or held at the time a business meeting is called by the president at a general session or announced on the program.

VII. The time allotted to the presentation of a single paper should not exceed fifteen minutes unless extended time is granted by vote of the section. Presidential addresses and those of guest speakers, as well as special invitation papers read by members, are without time limit.

VIII. Section programs may be arranged by the secretary with the advice of the section chairman. The subdivision or combination of existing sections shall be dependent upon the number of papers to be presented. Such changes shall be made by the secretary in accordance with the policies of the Academy and after receiving the advice of the chairman of the sections concerned.

IX. Section chairmen for the ensuing year shall be elected annually at the close of the section meetings.

X. Section programs may be held at any time of the annual session except during the time devoted to the business meetings and general sessions.

XI. Academy members, not in arrears in dues, have the privilege of submitting papers for publication in the *Transactions* to the editorial board. The editorial board, however, shall have the right to solicit papers by invitation from any author, irrespective of the author's membership in the Academy.

Botanical Notes: 1947

FRANK U. G. AGRELIUS
Kansas State Teachers College, Emporia, Kansas

"The Unusual is Usual in Kansas."

The cool, wet weather of the spring caused plant activities to be late, too. We consider ourselves fortunate if we have a few peony blossoms for Decoration Day. They were abundant and fine this time and were still blooming June seventeenth. The temperature of 34° on May twenty-ninth, with much frost and ice here and at near-by points, might indeed have been fatal, but peonies were not harmed. Some plants were damaged. Climbing roses suffered from the weather of the previous winter. *Forsythia* had but few blossoms.

In addition to the peony, other late bloomers were the wild *Columbine* as late as July eighth. Hollyhocks showed flowers much of the summer. The last were frozen on November eleventh. *Gaura biennis* had many flowers on October 25th. There were some *Chamaecrista fasciculata* on the same date.

The Black Walnut (*Juglaus nigra*) nut crop was quite spotted. A tree at our home produced plentifully. A group of these trees on the banks of the Neosho river about a mile distant and that commonly fruited well had none.

Owners of lawns were seriously plagued with a Chickweed (*Stellaria media*) and Nimble Will (*Muhlenbergia schreberi*). Nor are these by any means the only trouble makers. If a weed is a plant out of place then many more might be added. Tomato wilt does strike even on wilt resistant varieties. Some of the roses are harmed seriously by mildews. *Sclerotinia* plays mischief with the plum. A small *Sedum* chosen for use on the rock garden decided it did not want to be limited to the rocks and is spreading throughout the garden. It is difficult to eradicate. One of the serious pests is the so-called "Cedar Apple" caused by a *Gymnosporangium*. We dug out a fine specimen of *Bechtel's Flowering Crab Apple* to assist in controlling the disease; nevertheless, ordinary apple trees were seriously harmed by the aecial stage of the disease. Perhaps the climax of our weeds might be found as a result of a decidedly useful plant growing out of its proper place. This is none other than the seedlings of our great friend, the American elm. Nor do these little trees seem to have any worries about the so-called "Dutch Elm Di-

sease." Nor are they apparently affected by any harmful virus. The only way we find to meet this situation is to uproot each individual plant and this is not a small matter when one considers their numbers.

The white Evening primrose (*Oenothera speciosa*) staged a comeback and resulted in a fine showing along the roadsides.

The most outstanding item, perhaps, for this year, was the super-abundance of fruit on the Tartarian honeysuckle (*Lonicera tatarica*). Branches that would ordinarily be as much as six or eight feet above the earth were bent to within a foot or so from the ground due to the weight of the fruit. This last item was of particular interest to robins and other birds.

Transactions
Kansas Academy of Science

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The Geography of Kansas

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It is a surprising fact that in the 94 years that have elapsed since Kansas Territory was organized in 1854 there has never been prepared a comprehensive geography of Kansas. Brief accounts of Kansas geography have appeared in many school-book texts in these intervening years but no authoritative and extensive review has been made. The TRANSACTIONS *is therefore very happy to present the first in a series of articles on Kansas geography by one of the state's leading geographers. The series will be continued in future issues of the* TRANSACTIONS *but not necessarily in the consecutive issues which follow the present number. The first article in the series deals, as the reader can see, with political geography; the second will review the physiography of the state; the third article will consider rivers, streams and hydrology in general of Kansas; and the concluding article will deal with some aspects of Kansas economic geography. For further information concerning the author see page 289.*—The Editor.

Part I
POLITICAL GEOGRAPHY
Geographic Position and Coordinates

Geographically Kansas is the heart of the Nation. Its central position among the states is indicated by the fact that the north boundry of Kansas is approximately 620 miles south of the United States-Canada international line; its south border lies 700 miles north of the United States-Mexico line; the Atlantic sea board is 1,100 miles east of the east border of the State, and the Pacific coast is 1,130 miles distant from the Kansas-Colorado line.

The geographic coordinates or latitudes and longitudes of Kansas are given in Table 1.

In 1850 Congress ordered that the meridian of the observatory at Washington was to be used for all astronomic purposes (Douglas, 1939, p. 206; 9 Stat. L. 515); the act however, was repealed in 1912 (37 Stat. L. 342). Whereas the 1850 act of Congress placed the west boundry of Kansas precisely on a whole numbered meridian (25th) in relation to Washington, it unfortunately gave the west limiting Kansas meridian a fractional value when later all astronomic positions were again referred to the Greenwich meridian. The Washing-

ton meridian which was the one passing through the center of the dome of the old Naval Observatory had a longitude of 77°03′02.3″ west of Greenwich. Thus it is that the longitude of the Kansas-Colorado line or the 25th meridian west of Washington is 102°03′ 02.3″ a longitude which undoubtedly never would have been selected if at the time when the boundary lines of the State were determined, the Greenwich meridian had been used instead of the one at Washington. The State's west boundary line is 2.8 miles west of the 102° meridian in the southwest corner. (Douglas, 1939, p. 206).

Table 1. Geographic Coordinates of Kansas

Boundary line	Defined by Congress	Coordinates	Government Surveys Authority
North	40° N. latitude		
South	37° N. latitude	36° 59′ 55.2″	U. S. Geol. Survey
		36° 59′ 54.98″	U. S. Coast & Geodetic Survey
		36° 59′ 54.73″	U. S. Coast & Geodetic Survey
West	25th Meridian west of Washington	102° 03′ 02.3″	U. S. Geol. Survey
		102° 12′ 38.4-45.1″	General Land Office
East	Meridian line passing through the middle of the mouth of Kansas River, where the same empties into Missouri River—boundary south of mouth of Kansas River. For line north of Kansas River middle of main channel of Missouri River.	94° 37′ 03.4″	U. S. Geol. Survey

Geographic Centers and Geodetic Datum

Kansas has the distinction of having within its borders two significant landmarks. One of these is the geographical center of the United States exclusive of Alaska; the other is the Meades Ranch triangulation station or the geodetic datum known as the North American datum of 1927. Of these two landmarks the North American datum of 1927 is of the greater importance.

Geographic center of the United States.—The geographical center of the United States exclusive of Alaska is about 1 mile north and 1 mile west of Lebanon or 11 miles east and 4 miles north of Smith Center in Smith County. More precisely it is in White Rock township, in the SE¼ sec. 32, T. 2 S.,R. 11 W. (Schoewe, 1940, p. 305). Its geographical coordinates are 39° 50′ north latitude and 98° 35′ west longitude (Deetz, 1918, p. 57). The proximate site* of the geographical center of the United States is indicated by a stone monu-

*There is no entirely satisfactory method of determination of a center of any state, county, or continent (Adams, 1932, p. 586). The geographical center of any area is that point on which the surface of the area would balance if it were a plane of uniform thickness, or in other words the center of gravity of the surface (Douglas, 1939, p. 253). The location of the geographic center of the United States was determined by the U.S. Coast & Geodetic Survey by constructing an equal-area map of the United States on thin cardboard, cutting out the outline map along its various boundaries and ascertaining the center of gravity of the map by suspending it from a point and drawing a verticle line on the map from the point of suspension and repeating the process from a second point so that the second vertical line was approximately at right angles to the first. The intersection of the two lines is the center of gravity or the geographical center.

The location of the monument in the southeast corner of section 32 erected by the Hub Club of Lebanon on the instigation of the Kansas Academy of Science and dedicated on June 29, 1941, may be considered for all practical purposes as marking the geographical center of the United States, although the intersection of latitude 39′50′ with longitude 98° 35′ determined by the U.S. Coast and Geodetic Survey as the position of the geographical center lies approximately 2,270 feet northwest of the monument.

ment (Fig. 1) erected at the southeast corner of section 32 by the Hub Club of Lebanon.

Geographic center of Kansas.—The geographical center of the United States is not to be confused with the geographical center of North America which is in Pierce County, North Dakota, a few miles west of Devils Lake (Douglas, 1939, p. 254), nor with the

Fig. 1. Geographical center of the United States. Monument erected by the Hub Club of Lebanon. Dedicated June 29, 1941. SE 1/4 sec. 32, T. 2 S., R. 11 W., Smith County, 39° 50′ north latitude, 98° 35′ west longitude.

geographical center of the State of Kansas. The geographical center of Kansas is in Barton County, 15 miles northeast of Great Bend.

Geodetic datum of North America.—Considerable confusion prevails in regard to the differentiation between the geodetic datum of North America and the geographic center of the United States. To many the terms are synonymous. The geographic center as pre-

viously indicated refers to that point on which the surface of the area would balance if it were a plane of uniform thickness or the center of gravity of the surface. The geodetic datum, on the other hand, is the selected point on the earth's surface whose position (latitude and longitude) has been determined on the basis of an adopted spheroid of the earth, which is taken to represent the earth's

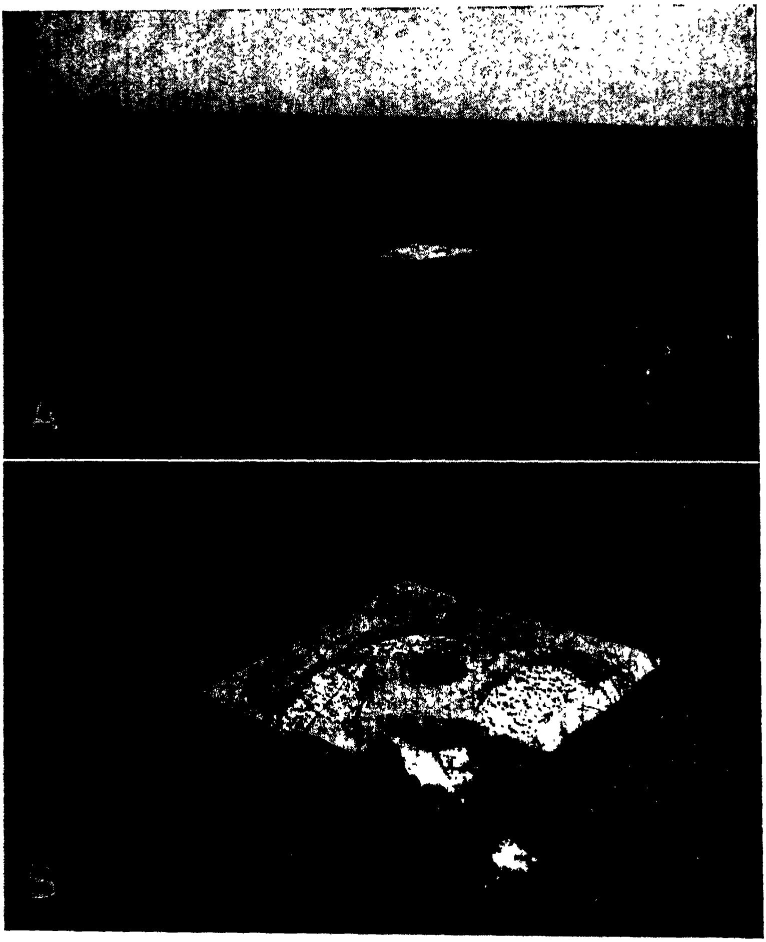


Fig. 2. (A) General view of the North American datum of 1927 on pasture land known as Meades Ranch in the SW 1/4 sec. 34, T. 9 S., R. 11 W., in Osborne County, Kansas, 39° 13′ 26.686″ north latitude, 98° 32′ 30.506″ west longitude.

(B) Close-up view of the North American datum seen on August 11, 1947. Sides of the station marker coincide with cardinal directions with SE corner toward observer. Station marker to be repaired according to Director of the U.S. Coast and Geodetic Survey.

shape, and whose azimuth (direction) to another triangulation station is known.

The geodetic datum is on pasture land (Fig. 2A) known as Meades Ranch in Osborne County at a place 8 miles east and 14½ miles south of the intersection of county road 388 with Highway K-8 in the east part of the city of Osborne, the county seat. It is approximately 40 miles due south of the geographical center of the United States. More specifically, this important landmark is in the SE¼ SE¼ NW¼ SW¼ sec. 34, T. 9 S., R. 11 W. (Schoewe, 1948, p. 117). Its geographical coordinates as determined by the U.S. Coast and Geodetic Survey are: 39° 13′ 26.686″ north latitude and 98° 32′ 30.506″ west longitude (U.S. Coast and Geodetic Survey, 1941, p. 14). The site of this geodetic datum, known officially as the North American datum of 1927, is marked at present (August 11, 1947) by a 24-inch square concrete slab which projects several inches above the ground (Fig. 2 B). In the center of the slab is imbedded a circular bronze disk inscribed "U. S. Coast and Geodetic Survey, Meades Ranch, 1891".

Unlike the geographical center, which is of great public interest as evidenced by the thousands of visitors who have recorded their presence in the registration book at the monument site but which has no practical or scientific significance, the geodetic datum is of utmost practical and scientific value. It is the point of origin for all Federal mapping in the United States as well as in Canada and Mexico. The tens of thousands of control points included in the extensive network of triangles and quadrilaterals which make up the American system of triangulation are all coordinated with the geodetic triangulation station or datum on Meade's Ranch in Osborne County and serve as the control points for the various types of surveys—topographic, geologic, hydrographic, those needed in engineering construction, and others.*

Boundaries of Kansas

Boundaries defined by Enabling Act.—Kansas was admitted into the Union on January 29, 1861. According to the Enabling Act (12 Stat. L. 126) the boundary lines of the State are defined as follows.

". . . the said State shall consist of all the territory included within the following boundaries, to wit: beginning at a point on the western boundary of the State of Missouri, where the thirty-seventh parallel of north latitude crosses the same; thence west on said parallel

*For detailed description, origin, etc. of the geodetic datum of North America, see Schoewe, Walter. H., (1948).

to the twenty-fifth meridian of longitude west from Washington; thence north on said meridian to the fortieth parallel of latitude; thence east on said parallel to the western boundary of the State of Missouri; thence south with the western boundary of said State to the place of beginning".

The boundary lines thus defined are the present boundary lines of the State. All the boundary lines of the State are definitely fixed except for a portion of the east line north of the junction of Kansas and Missouri Rivers. Confusion as to the exact location of the State line has been brought about by the frequent shiftings of the main channel of Missouri River. Negotiations between Kansas and Missouri are now in progress to establish definitely the position of this part of the Kansas-Missouri state line.

Lengths of State lines.—According to the records of the original official surveys in the files of the General Land Office (Harrington, 1945) the total length of the Kansas boundary lines is 1,219 miles (Table 2).

Table 2. Length of Kansas Boundary Lines

Boundary		Miles
North 40th parallel of latitude		356.66
South 37th parallel of latitude		411.18
West 25th meridian west of Washington		207.33
East South of mouth of Kansas River	142.84	
North of mouth of Kansas River up the middle of Missouri River	101.	
	243.84	243.84
Total length of Kansas boundaries		1,219. *

*Note that since the distance "North of mouth of Kansas River up the middle of Missouri River" is known only to the nearest mile, the total length of the Kansas boundaries will be known only to the nearest mile, i.e. 1219 miles.

Dates of the surveys of the boundaries.—The southern boundary of Kansas was surveyed at different times. According to Douglas (1939, p. 215) the south line was surveyed in 1857 from an initial point on the 37th parallel which from astronomic observation on the Kansas-Missouri boundary line was determined as in longitude 94° 40′26.3″. That part of the south line between mileposts 166 and 226 was resurveyed in 1872 and from the 207th mile to the 268th mile in 1873 by the General Land Office. The initial point on the south boundary surveyed by the General Land Office was on the west bank of Neosho River in sec. 33, T. 35 S., R. 22 E. The line was run through R. 25 W. in 1871. In 1874 the line was completed between R. 26 W. and the southwest corner of the State in R. 43 W. (Wills, 1945). Two boundary stones on the Kansas-Oklahoma line were located by triangulation in 1902. Boundary stone No. 160 is a sandstone post 5 by 12 by 20 inches, projecting about 9 inches above the ground. It is marked "160" on top, "K" on the north side, and "IT" (Indian Terri-

tory) on the south side. The stone marker is in latitude 36° 59′ 54.-98″, longitude 97° 54′ 01.98″. The other boundary stone is No. 163 and similar to No. 160, except for the number. It is located in latitude 36° 59′ 54.73″, longitude 97° 57′ 16.45° (Douglas, 1939, p. 215; U.S. Coast and Geodetic Survey Rept. for 1903, p. 885).

The west boundary was surveyed in 1872. According to Douglas (1939, p. 216) the western boundary from the 174th milepost south to the Oklahoma line was established in 1908 by the General Land Office. The survey for the north boundary line of Kansas which serves as the base line for land surveys in Kansas and Nebraska was begun in 1854. The line extended for 108 miles west of Missouri River or to the 6th Principal Meridian. The line was re-run in 1855-1856. The survey west of the 6th Principal Meridian or the 108th mile was made in 1858-1859. The eastern boundary of Kansas south of Missouri River was established in 1823. According to the Enabling Act of Congress on March 6, 1820, which made Missouri a state (March 2, 1821) the west boundary of Missouri was defined as the meridian passing through the middle of the mouth of Kansas River, where the same empties into Missouri River. In 1836 the boundary line of Missouri north of the mouth of Kansas River was extended to Missouri River by the Missouri State Legislature, an act ratified by Congress on June 7, 1836, and declared in effect by presidential proclamation on March 28, 1837 (5 Stat. L. 34; Douglas, 1939, p. 202). The west boundary of Missouri or the east line of Kansas was re-surveyed and re-marked in 1844-1845 (Douglas 1939, p. 203).

Selection of boundary lines.—The present boundary lines of Kansas were determined by the Wyandotte Constitutional Convention of 1859 although all of them with the exception of the west boundary had been established previously. The north boundary or the 40th parallel was fixed by act of Congress in May, 1854, when the territories of Kansas and Nebraska were organized. This boundary line was retained by the Wyandotte Constitutional Convention five years later. Attempts, however, to have the north boundary line of Kansas placed at the Platte River in southern Nebraska were turned down by the convention by a vote of 19 to 29 (Gaeddert, 1940, p. 59) (Fig. 3). The Republican delegates feared that the inclusion of the Platte country would result in giving the Democrats political control in organizing the state government since southern Nebraska was considered a Democratic stronghold (Gaeddert, 1940, p. 58). The question of the location of the capitol of the State also was a factor in the final decision of the north boundary line. S. D. Houston, a Re-

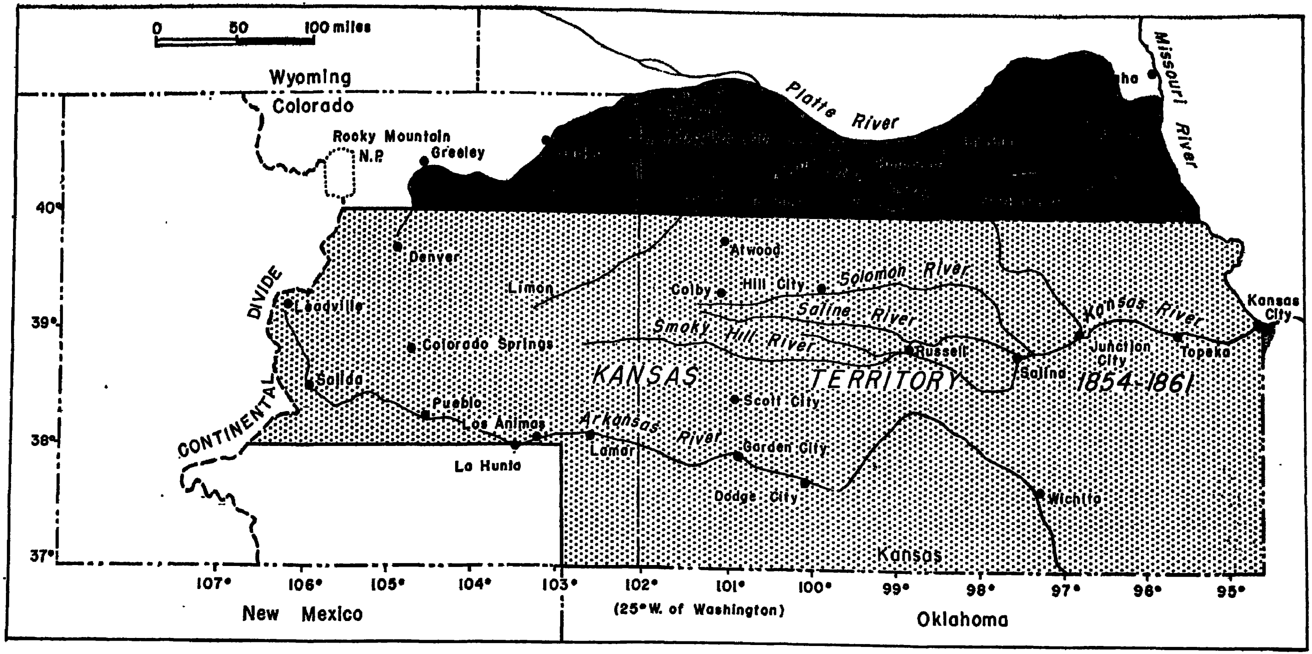


Fig. 3. Map showing Kansas Territory, area south of Platte River proposed by a Nebraska delegation in 1859 to be included as part of Kansas, and the Kansas City, Missouri, area proposed in 1879 for annexation to Kansas. (See detailed map, fig. 4).

publican delegate from Riley County favored annexing the Platte region for several reasons. Houston vigorously attempted to place the west boundary line of Kansas at the 27th meridian and favored Manhattan as the seat of State government. By including the Platte country as part of Kansas, Houston believed his chances were greatly enhanced for extending the west boundary to the 27th meridian and making Manhattan the site of the capital. Delegates from Topeka and Lawrence, however, opposed Houston for fear of weakening their chances to make Topeka or Lawrence the capital of the State (Martin, 1910, p. 71). By excluding the Platte county, Kansas lost the rich agricultural lands of southern Nebraska as well as the advantages of the Pacific railroad which was being organized at that time and which played an important role in the early development of that part of the country.

The west boundary line was established by the Wyandotte Constitutional Convention in 1859. Houston of Riley County proposed and vigorously fought to have the west boundary line located at the summit of the Rockies as given in the Organic Act (Martin, 1910, pp. 64, 65). On July 28, one day before the final adjournment of the convention, Caleb May of Atchison proposed to change the west limits of Kansas from the 23rd meridian which had been agreed upon by the convention to the 26th meridian (103°03′02.3″ between Lamar and Las Animas, Colorado) (Drapier, 1859, pp. 264, 537, 546) or to the northern extension of the east line of New Mexico. May, however was prevailed upon to change his proposal to the 25th meridian which he did and which was then unanimously accepted and fixed by the convention. The 24th meridian (101°03′02.3″ Atwood, Garden City, Liberal, Scott City, Colby) was also suggested as the west boundary line of the state (Martin, 1910, p. 63) as was the 23rd meridian (100°03′02.3″, Hill City, Fort Dodge) (Drapier, 1859, pp. 230, 231, 235, 244, 248, 250, 260, 264, 463, 534, 537).

The south boundary line of Kansas was established to coincide with the 37th parallel by act of Congress approved on May 30, 1854, (10 Stat. L. 277, 283) when the territories of Kansas and Nebraska were organized. Originally the south border line of the proposed Territory of Nebraska which was later divided by the 40th parallel into the Territories of Nebraska and Kansas was fixed at 36° 30′ (Martin, 1910, Addenda, p. xvi), the same parallel that constitutes the south border line of Missouri. According to United States Senator Douglas of the Committee on Territories, in discussing the Nebraska bill the chairman of the committee on Indian affairs called

attention to the fact that the proposed south boundary line of 36°30′ would divide the Cherokee country, whereas the 37th parallel would run between the Cherokee and Osage lands. In order not to divide the lands belonging to the Cherokee Nation the committee on territories concluded not to use the 36°30′ parallel as the south line of the proposed divided Nebraska territory. In a letter written by Mr. John Francis, Jr., Acting Chief Land Division, Washington, D. C., to Mr. Martin, Secretary, Kansas Historical Society, under date of March 24, 1910, the 37th parallel did not form the dividing line between the Cherokee and Osage Nations (Martin, 1910, p. 55). It is believed that a map of Kansas and Nebraska dated August 5, 1854, endorsed by George W. Manypenny, Commissioner of Indian Affairs, and erroneously showing the 37th parallel as the dividing line between the Osage and Cherokee Nations, might have influenced the selection of the 37th parallel as being the "least liable to arouse controversy" (Miller, 1932, pp. 104-105). In fixing the south line of Kansas at the 37th parallel all Indian lands included in the territory were excluded and not considered part of the State of Kansas until such Indian lands were ceded to the State. It was not until February 23, 1867, when the Quapas, the last of the Kansas tribes, ceded their rights to Kansas, that the 37th parallel became the permanent south border line of the State (Miller, 1932, pp. 104, 105).

The east boundary line of Kansas is the west line of Missouri. That portion of the line south of the junction of Kansas River with Missouri River dates back to March 6, 1820, when in the Enabling Act the west boundary of Missouri was defined as the meridian passing through the mouth of Kansas River where said river empties into Missouri River. The boundary line between the two States north of the junction of Kansas and Missouri Rivers was fixed on June 7, 1836, when Congress ratified the act passed by the Missouri State Legislature in the same year extending the State's west border to the middle channel of Missouri River. This ratified act was declared in effect by presidential proclamation on March 28, 1837 (Douglas, 1939, p. 202; 5 Stat. L. 34).

The east boundary line of Kansas has been the subject for controversy concerning the state line between Kansas and Missouri on several occasions (Connelley, 1910, p. 75) and as recently as 1944. According to Connelley (1910, p. 75) in 1884 many Kansans placed the state line as much as 6 miles east of its present position and in 1899 at the foot of Broadway Street in Kansas City, Missouri. The difficulty in establishing the location of the State line hinged on the

determination of the position of the "middle of the mouth of the Kansas river where the same empties into the Missouri river," as stated in the Enabling Act of 1820 which defined the borders of Missouri. The meridian passing through the middle of the mouth of Kansas River was surveyed and established in 1823 by Joseph C. Brown. The mouth of the river was definitely and accurately located in 1804 by Lewis and Clark whose description fits well the 1899 location (Connelley, 1910, p. 76). The meridian passing through the middle of the mouth of Kansas River was determined by the United States Geological Survey in 1906 to be 94°37′02.9″ (Douglas, 1939, p. 203; Marshall, 1910, p. 488).

The east boundary line north of the confluence of Kansas and Missouri Rivers is still unsettled and is in the process of litigation. The line between the two states north of Kansas River was defined "as the middle of the main channel of the Missouri River" when Congress ratified the act of the Missouri State Legislature in 1836 to extend its west state boundary to Missouri River. The frequent shifting of the channel of the Missouri has caused considerable confusion to Kansans and Missourians living in the valley of Missouri River in regard to the position of the state line and to the jurisdiction under which they live, vote, and pay taxes, and concerning matters regarding law enforcement. In order to establish definitely the boundary line between the two states, Kansas brought suit against Missouri to settle the dispute. In June, 1944, the United States Supreme Court, after adopting the report of a special master, held that the Missouri River in its entirety was no longer the official boundary line and directed that markers be placed along a new line determined by the special master (K. C. Times, 1948, p. 13). The dispute between the two States involves five parcels of land of which there are 190 different descriptions and which total about 4,000 acres. The decision of the United States Supreme Court in regard to the fixation of the boundary line under dispute was not favorably acceptable to both Kansas and Missouri. As a result, and at the request of both states, the United States Supreme Court held in abeyance the appointment of a boundary commission until the two states could come to an agreement of settlement. On March 5, 1945, the Kansas Senate approved a resolution introduced by the Committee on Federal and State Affairs to study and settle this matter pertaining to the disputed parcels of land. According to the resolution, the plan proposed was for Kansas and Missouri to trade certain parcels of land and to interview the owners to see whether they desire to remain under the jurisdiction of Kansas or of Missouri. If the trade of lands

can be accomplished, then each legislature will enact appropriate legislating ceding jurisdiction of certain lands to the other state. A similar resolution was passed later by the State Legislature of Missouri. The Kansas and Missouri Commissions on Interstate Cooperation met Friday, May 7, 1948, at Kansas City, Missouri, and agreed that "the Kansas territory on the east side be exchanged for Missouri land on the west side of the river" (Lawrence Daily Journal-World, May 8, 1948, p. 1). They also agreed to recommend (on the basis of a report of the Army engineers that the present river channel is now stable and that there will be little if any channel change in the future) that the present river channel be designated the official boundary between the two states.

Before the present channel of Missouri River, however, can become the legal boundary between Kansas and Missouri it will be necessary first for the State Legislature of both states to approve the recommendation of the Commission on Interstate Cooperation. The Federal Congress will have to ratify the action of both state legislatures. The Kansas Commission planned to convene on June 4, 1948, at Topeka to hear from the landowners.

Area of Kansas

The total area of Kansas is 82,276 square miles, of which 82,113 constitutes land area and 163 square miles inland water area (Batschelet, 1942, p. 6, table 1). In land area Kansas ranks 12th among the states, whereas in total area, including land and inland water areas, Kansas claims 13th place. All the larger states except Minnesota and a part of Texas are west of Kansas. The 13 largest states with their respective ranks are presented in Table 3.

Table 3. Land, Water and Total Area of the 13 Largest States

	Area (sq. miles)			Rank	
	Land	Water	Total	Land area	Total area
Texas	263,644	3,695	267,339	1	1
California	156,803	1,890	158,693	2	2
Montana	146,316	822	147,138	3	3
New Mexico	121,511	155	121,666	4	4
Arizona	113,580	329	113,909	5	5
Nevada	109,802	738	110,540	6	6
Colorado	103,967	280	104,247	7	7
Wyoming	97,506	408	97,914	8	8
Oregon	96,350	631	96,981	9	9
Utah	82,346	2,570	84,916	11	10
Minnesota	88,009	4,059	84,068	13	11
Idaho	82,808	749	83,557	10	12
Kansas	82,113	163	82,267	12	13

Former extent of Kansas.—Previous to 1854 Kansas was part of the great territory known as the Territory of Louisiana and later in 1812 (2 Stat. L. 743) as the Territory of Missouri. This territory included all the original Louisiana Purchase, except the State of

Louisiana. The Territory of Kansas was organized on May 30, 1854. It included a land area vastly greater than the present area of Kansas (Fig. 3). According to the act of organization the Territory of Kansas included all that land lying within the following limits (10 Stat. L. 283):

". . . beginning at a point on the western boundary of the State of Missouri, where the thirty-seventh parallel of north latitude crosses the same; thence west on said parallel to the eastern boundary of New Mexico; thence north on said boundary to latitude thirty-eight; thence following said boundary westward to the east boundary of the Territory of Utah, on the summit of the Rocky Mountains; thence northward on said summit to the fortieth parallel of latitude; thence east on said parallel to the western boundary of the State of Missouri; thence south with the western boundary of said State to the place of beginning."

On the basis of our present geography the Territory of Kansas included 126,283 square miles (Andreas, 1883, p. 33) or all the present State of Kansas plus that part of Colorado lying between the Kansas-Colorado line (practically the 102d meridian) and the 103d meridian extending from the southern boundary of Colorado and Kansas (37° N. latitude) to the 38th parallel, in addition to the greater part of eastern Colorado bounded on the south by the 38th parallel, on the west by the continental divide or summit of the Rocky Mountains, and on the north by the 40th parallel (Fig. 3). When Kansas became a state it lost the vast coal fields of eastern Colorado, some of the gold and silver districts, part of the vast recreational areas of the Rocky Mountains, and the great farming area of the irrigated districts and high prairie country of eastern Colorado (Howes, 1942, p. 30).

Kansas might also have been a larger State if the pleas of the Nebraska delegation represented at the Wyandotte Constitutional Convention had been followed. The Nebraska delegation sitting in on the convention without voting privileges, however, urged the convention to include within the area of Kansas that portion of Nebraska lying south of the Platte River (Fig. 3). This, however, the convention refused to do.

Kansas too might have been larger by 60 square miles if in 1855 and again in 1879 the efforts of not a few persons both in Kansas and in Missouri had been successful in annexing Kansas City, Missouri, to Kansas (Martin, 1910, pp. 72-74, Addenda, pp. xvii and xviii). The plan to annex Kansas City, Missouri, to Kansas included

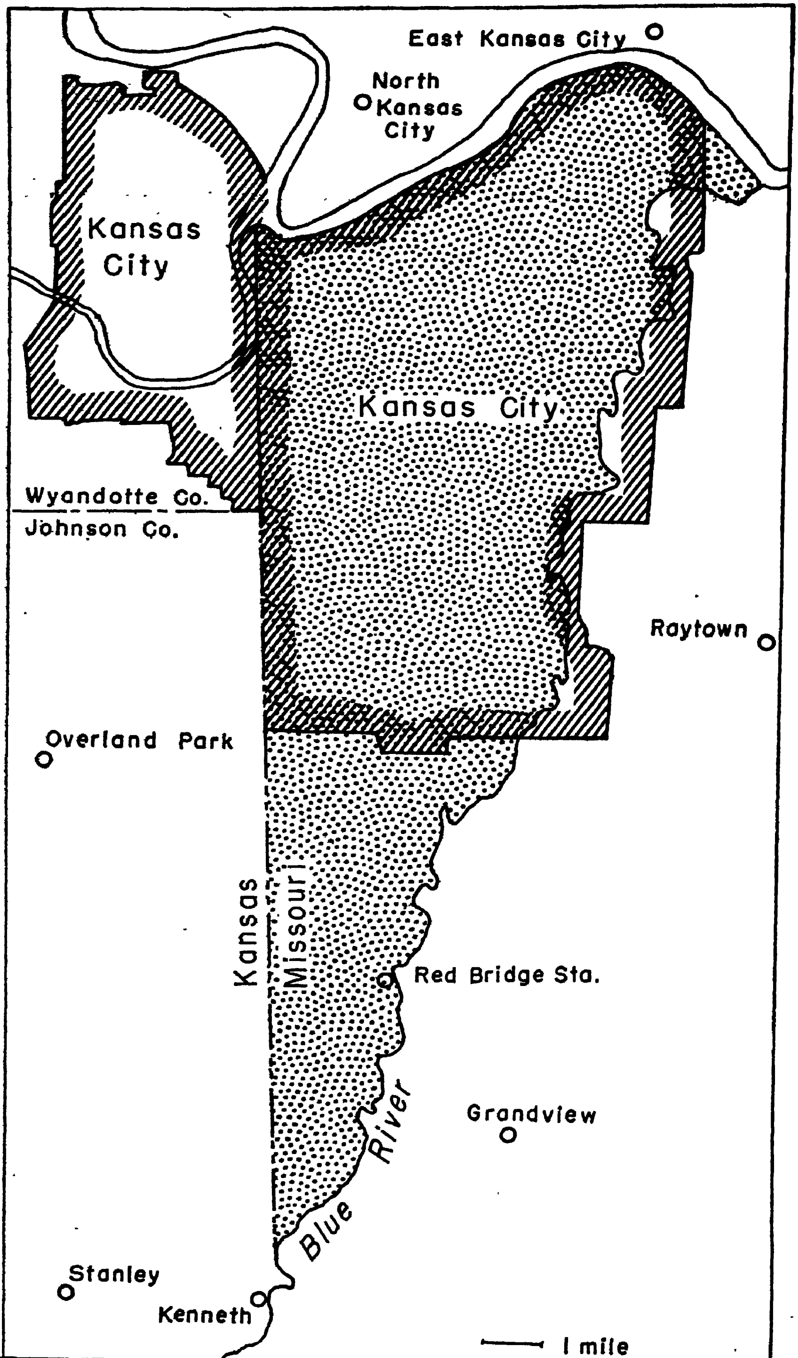


Fig. 4. Map showing area between the Kansas-Missouri State line and Blue River in Missouri proposed for annexation to Kansas in 1879.

all lands in Missouri lying north and west of Big Blue River from a point on the state line near the southeast corner of Johnson County to the junction of that river with Missouri River (Fig. 3 and 4). Although the plans were agreeable to the Kansas and Missouri State Legislatures, to the citizens of Kansas City, and in general to Congress, the plans for annexation did not materialize.

The evolution of Kansas from unorganized territory to its present shape and size is shown by maps in Figure 5. Of special historical interest is the fact that the southwestern part of the State comprising an area of approximately 7,200 square miles south of Arkansas River and west of Dodge City and the 100th meridian has been under the jurisdiction of four other nations: England, France, Spain, Mexico and the Texas Republic (Fig. 6). Spain (1492), England (1497), and France (1682), all claimed the territory west of Mississippi River as theirs on the basis of early exploration. In 1762 France ceded her right to the territory to Spain who, however, in 1800 relinquished her claim again to France. In 1803 the United States purchased the Territory of Louisiana, as the area was then known, from France for a total of $23,213,567.73 (Douglas, 1939, p. 29). In 1819 the United States made a treaty with Spain by which the southwestern part of Kansas was included as part of Spanish New Mexico. Two years later, in 1821, Mexico won her independence from Spain and thus southwest Kansas came under the jurisdiction of Mexico. In 1835 Texas won her freedom from Mexico and became a republic, thus causing the flag of Texas to fly over southwest Kansas until 1845 when Texas was admitted as the 28th state in the Nation. The historical relationships of Kansas Territory and Kansas to French Louisiana and the territory claimed by England, Spain, Mexico, and Texas Republic are shown in Figure 6.

Political Subdivisions

Counties.—Politically Kansas is subdivided into 105 counties of which Butler, with 1,445 square miles is the largest, and Wyandotte, 159 square miles, is the smallest. The Wyandotte Constitutional Convention of 1859 provided for the division of Kansas into counties. Previous to this time, however, the territorial legislatures had created 47 counties in the Territory of Kansas. Of this number 33 were officially organized and 14 unorganized. The unorganized counties were attached to neighboring organized counties for civil and military purposes. Of the 47 created counties five organized and one unorganized were in what is today the State of Colorado. In 1861 when Kansas became a state, 49 counties (28 organized and

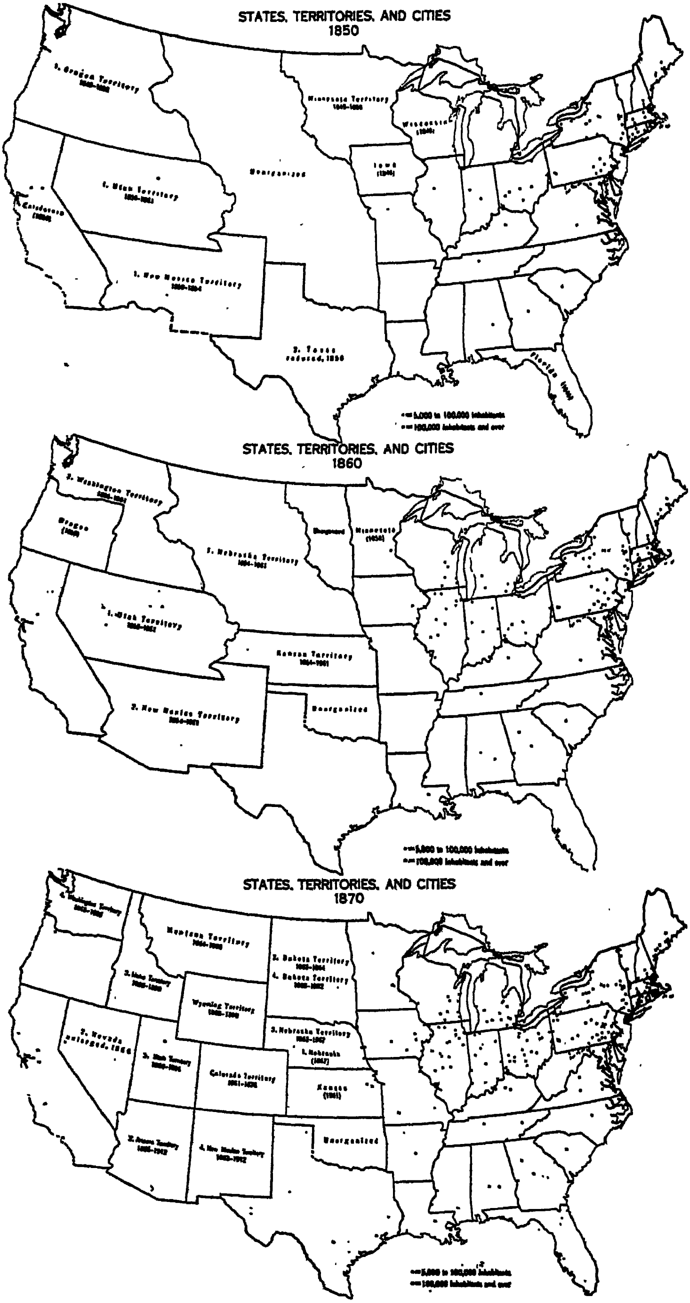


Fig. 5. The changing map of the United States 1850-1870. Notice particularly the position of Kansas as it develops from an unorganized and unknown region to the territory of Kansas and eventually into its present state. Adapted from Charles O. Paullin's Atlas of the Historical Geography of the United States (1932) by permission of the Carnegie Institution of Washington and the American Geographical Society of New York.

21 unorganized) (Table 4) were in existence within the present limits of the State. On February 11, 1859, the Kansas Territorial Assembly approved the constitutional act, an act providing for the formation of a constitution and state government for the State of Kansas. According to section 4 of this act the convention was to consist of 52 delegates which were to be apportioned from the 23 districts of the Territory comprising the following 38 counties, one of which was in the present State of Colorado: Allen, Anderson, Arapahoe (in Colorado), Atchison, Bourbon, Breckenridge, Brown, Butler, Calhoun, Clay, Coffey, Davis, Dickinson, Doniphan, Dorn, Douglas, Franklin, Godfrey (also spelled Godfroy), Greenwood, Hunter, Jefferson, Johnson, Leavenworth, Linn, Lykins, Madison, Marshall, McGee, Nemaha, Pottawatomie, Richardson, Riley, Shawnee, Washington, Weller, Wilson, Wise, and Woodson. Considerable confusion, however, prevailed at the Wyandotte Constitutional Convention in regard to the representation of delegates from some of the counties. Between February 11, 1859, when the constitutional act became law and July 5 of the same year when the Wyandotte Constitutional Convention convened and organized, several changes in the organization of counties had been made. Wyandotte, Chase and

Table 4. Summary of County organizations

Year	Created	Organized	Unorganized	Name changed	Dissolved absorbed divided
1855	36*	17	19	—	—
1857	4	5	0	—	—
1859	7**	11**	0	3	—
1860	8	0	8	—	—
1861	—	—	—	3	1
1862	—	1	—	—	—
1864	—	1	—	—	3
1865	—	—	—	—	3
1866	—	2	—	—	—
1867	35	4	—	1	1
1868	2	—	—	—	—
1869	—	1	—	—	—
1870	—	6	—	—	—
1871-72	10	—	—	—	—
1873	22	7	—	1	—
1874	1	3	—	1	—
1875	—	2	—	—	2
1878	—	1	—	—	—
1879	—	4	—	—	1
1881	2	2	—	—	2
1883	1	—	—	—	—
1885	2	4	—	—	—
1886	3	10	—	—	—
1887†	3	5	—	1	—
1888	—	1	—	1	—
1889‡	—	3	—	1	—
1892§	—	—	—	—	1

* One county in present Colorado
** Five counties in present Colorado
† All created
‡106 counties
§ 105 counties

Morris Counties, organized in the interval, asked for representation at the convention. On July 29, 1859, the State constitution was

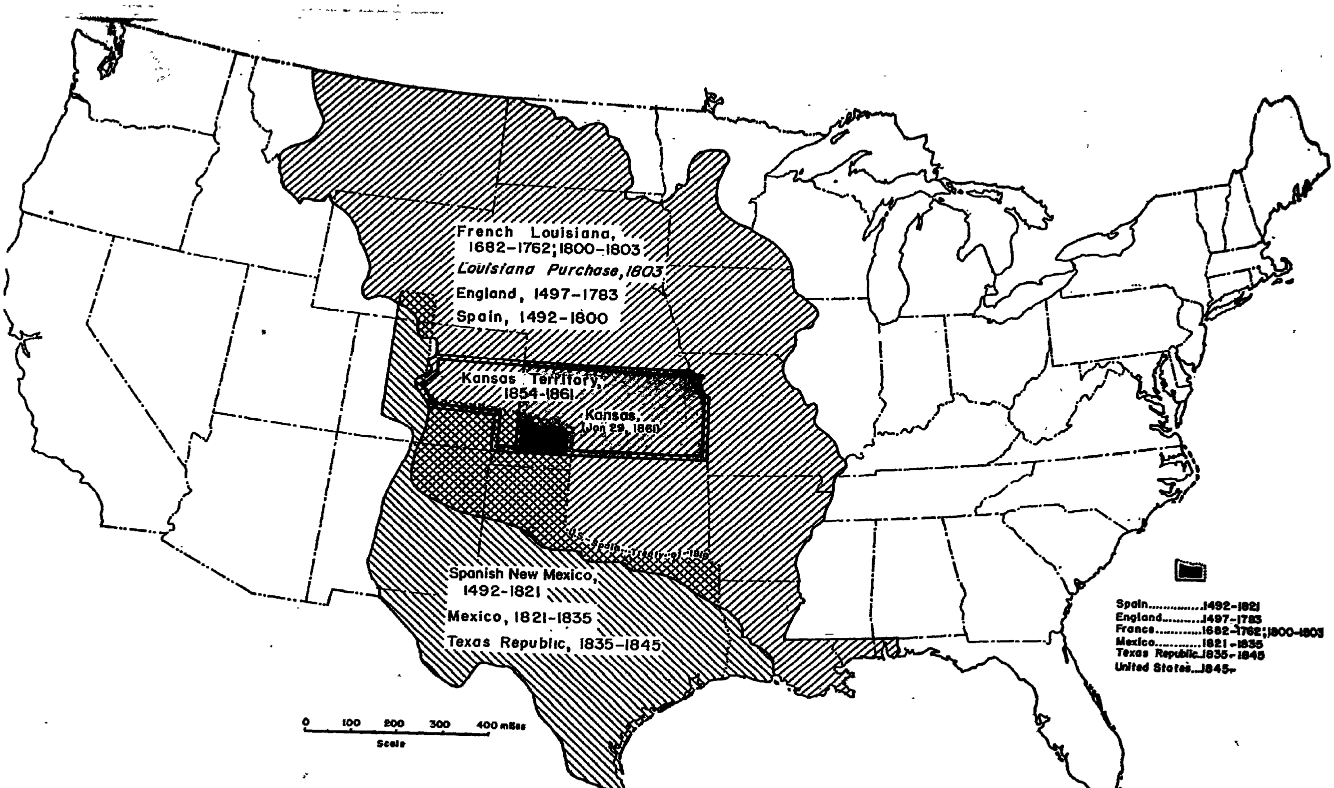


Fig. 6. Map showing historical relationships of Kansas Territory and Kansas to French Louisiana and the territory claimed by England, Spain, Mexico and Texas Republic.

adopted by the convention. According to article 10 (apportionment) of the constitution, 40 countries were reorganized, one of which, however, Arapahoe County, was not within the confines of the present State (Drapier, 1859, p. 585). On the basis of the list of counties officially recognized in section 3 of article 10 (apportionment) of the constitution, Wyandotte, Jackson, Wabaunsee, Osage, Chase, and Morrison Counties were included in the new list and Calhoun, Richardson, Weller, and Wise were deleted. No new counties were created in the State until 1867, when 35 came into being. Until 1887, when the last 3 Kansas counties were created considerable changes took place in the development of the counties, especially in regard to their names and limits. By 1889 the last of the counties, Grant, Greeley, and Kearney, had been organized. At that time Kansas had 106 counties. In 1892 the Kansas Supreme Court declared Garfield County illegally organized as it contained less than the required 432 square miles. The following year, 1893, Garfield County was annexed to Finney County, thus reducing the number of Kansas counties to the present 105. A summary of county organizations and other pertiment data are presented in Tables 4 and 6.

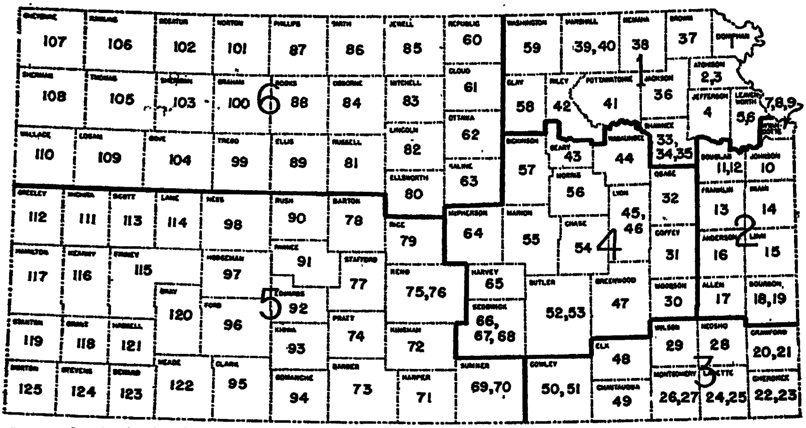
A survey of Kansas county development reveals the names of a number of counties which no longer are listed on the present roster of counties, but are found on the early maps of the State. These names are listed in Table 5.

Table 5. Names of early Kansas counties not now in use

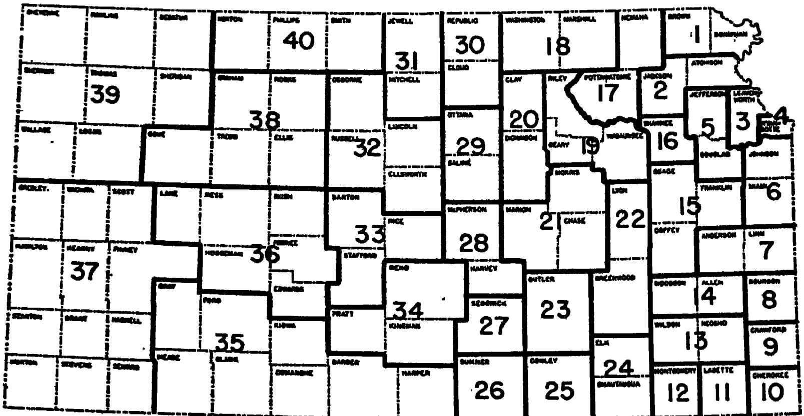
Arapahoe	Dorn	Lykins	Sequoyah
Billings	Garfield	Madison	Shirley
Breckenridge	Godfrey (Godfroy)	McGee	St. John
Buffalo	Howard	Otoe	Weller
Calhoun	Hunter	Peketon	Wise
Davis	Kansas	Richardson	

Most of the Kansas counties perpetuate the names of men. Among the counties, 17 bear Indian names, 2 were named in honor of free-state martyrs (Barber, Phillips) and 41 perpetuate the names of distinguished Civil War veterans. Eleven counties have the names of United States Senators and one each of a member of Congress and the United States Supreme Court. Seven counties, Anderson, Brown, Coffey, Geary, Johnson, Marshall and Woodson, were named for members of the Territorial legislature, 5 for other noted Kansans (Edwards, Gray, Haskell, Kingman, and Lane) and 16 for noted Americans. In addition 2 counties (Bourbon, Chautauqua) were named for counties in other states and 7 were named for rivers of which 4 are also Indian names.

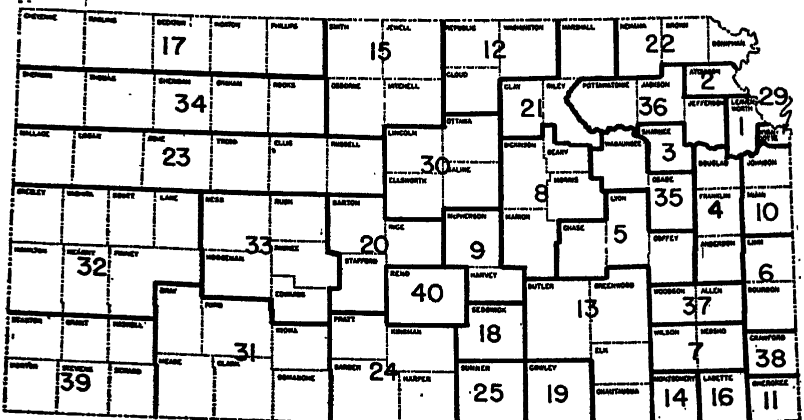
Other political divisions. In addition to counties, Kansas is also



Congressional Districts(large numbers,heavy borders) and State Representative Districts



Senatorial Districts



Judicial Districts

Fig. 7. Maps showing Congressional, State Representative, Senatorial, and Judicial Districts of Kansas.

sub-divided into 6 congressional districts (G.S. 1936 p. 37; G.S. 1947 Supp., 1948, pp. 353-354), and 125 state representative districts (G. 34), 40 judicial districts (G.S. 1935, 1936, p. 547-551; G.S. 1947 Supp., 1948, pp. 353-354), and 125 state representative districts (G. S. 1947 Supp., 1948, pp. 34-38). Assignment of counties to these various political districts with their respective district numbers is presented in Table 6, and Figure 7. (Ryan, 1948, pp. 126-134).

Table 6. Kansas counties

County	County Seat	Created*	Organized*	Area** sq. mi.	Population† 1947 March 1	Rank 1947	Auto†† Tag No.	Political Districts††† C	S	J	SR	Former Name
Allen	Iola	1855	1855	505	18,182	28	24	2	14	27	17	
Anderson	Garnett	1855	1855	577	10,203	57	52	2	7	4	16	
Atchison	Atchison	1855	1855	431	20,856	23	15	1	2	2	2, 3	
Barber	Medicine Lodge	1867	1873	1,146	8,333	66	67	5	35	24	73	
Barton	Great Bend	1867	1872	899	27,220	14	33	5	33	20	78	
Bourbon	Fort Scott	1855	1855	639	20,264	24	17	2	8	6	18, 19	
Brown	Hiawatha	1855	1855	578	15,543	33	25	1	1	22	37	
Butler	El Dorado	1855	1859	1,445	32,912	9	9	4	23	13	52, 53	
Chase	Cottonwood Falls	1859	1859	744	5,097	84	81	4	21	5	54	
Chautauqua	Sedan	1855	1875	647	7,516	70	63	3	24	13	49	Godfroy, Howar
Cherokee	Columbus	1855	1866	587	27,575	13	10	3	10	11	22, 23	McGee
Cheyenne	St. Francis	1873	1873	1,027	5,381	82	82	6	39	17	107	
Clark	Ashland	1867	1855	984	3,711	92	91	5	35	31	95	
Clay	Clay Center	1857	1866	659	11,516	45	41	1	20	21	58	
Cloud	Concordia	1860	1866	711	15,152	34	36	6	30	12	61	Shirley
Coffey	Burlington	1855	1859	656	10,779	51	44	4	15	5	31	
Comanche	Coldwater	1867	1885	800	3,889	91	90	5	35	31	94	
Cowley	Winfield	1867	1870	1,139	35,085	8	8	3	25	19	51	
Crawford	Girard	1855	1867	598	48,147	7	4	3	9	38	20, 21	McGee
Decatur	Oberlin	1873	1879	899	6,250	78	74	6	39	17	102	
Dickinson	Abilene	1857	1857	855	21,585	21	18	4	12	8	57	
Doniphan	Troy	1855	1855	410	11,288	48	45	1	1	22	1	
Douglas	Lawrence	1855	1855	474	27,021	15	16	2	5	4	11, 12	
Edwards	Kinsley	1874	1874	619	5,845	79	79	5	36	33	92	
Elk	Howard	1855	1875	647	6,830	74	68	3	24	13	48	Godfroy, Howar
Ellis	Hays	1867	1867	900	16,695	31	38	6	38	23	89	
Ellsworth	Ellsworth	1867	1867	723	9,376	59	64	6	32	30	80	
Finney	Garden City	1883	1884	1,302	11,680	44	71	5	37	32	115	
Ford	Dodge City	1867	1873	1,091	18,411	27	35	5	35	31	96	
Franklin	Ottawa	1855	1857	577	19,898	25	21	2	15	4	13	
Geary	Junction City	1855	1855	401	14,555	37	47	4	19	8	43	Davis
Gove	Gove	1868	1886	1,070	4,250	89	88	6	38	23	104	
Graham	Hill City	1867	1880	891	5,046	85	76	6	38	34	100	
Grant	Ulysses	1873	1888	571	2,909	96	103	5	37	39	118	
Gray	Cimarron	1881	1887	873	4,654	87	89	5	35	31	120	Buffalo, Foote
Greeley	Tribune	1873	1888	783	1,755	104	105	5	37	32	112	
Greenwood	Eureka	1855	1862	1,150	13,506	38	32	4	22	13	47	
Hamilton	Syracuse	1873	1886	992	2,717	97	100	5	37	32	117	
Harper	Anthony	1867	1873	801	10,456	52	51	5	35	24	71	
Harvey	Newton	1872	1872	540	21,097	22	28	4	28	9	65	
Haskell	Sublette	1873	1887	580	2,262	100	101	5	37	39	121	
Hodgeman	Jetmore	1867	1879	860	3,216	95	93	5	36	33	97	Hageman
Jackson	Holton	1855	1857	656	11,196	49	42	1	2	36	36	Calhoun
Jefferson	Oskaloosa	1855	1855	552	11,006	50	46	1	5	36	4	
Jewell	Mankato	1867	1870	915	10,017	58	43	6	31	15	85	
Johnson	Olathe	1855	1855	478	50,261	5	19	2	6	10	10	
Kearney	Lakin	1873	1888	861	2,559	99	98	5	37	32	116	
Kingman	Kingman	1867	1874	865	10,233	55	57	5	34	24	72	
Kiowa	Greensburg	1867	1886	720	4,547	88	85	5	35	31	93	
Labette	Oswego	1867	1867	654	31,888	11	11	3	11	16	24, 25	

†††C=Congressional district; S=Senatorial district; J—Judicial district; SR—State Represer tative district. Ryan, 1948, pp. 126-134

County	County Seat	Created*	Organized	Area** sq. mi.	Population† 1947 March 1	Rank 1947	Auto†† Tag No.	Political Districts††† C	S	J	SR	Former Name
Lane	Dighton	1873	1886	720	2,616	98	97	5	36	32	114	
Leavenworth	Leavenworth	1855	1855	472	30,273	12	7	1	3	1	5, 6	
Lincoln	Lincoln	1867	1870	726	7,339	72	66	6	32	30	82	
Linn	Mound City	1855	1855	608	11,490	47	49	2	7	6	15	
Logan	Russell Springs	1881	1887	1,073	3,710	93	95	6	39	23	109	St. John
Lyon	Emporia	1858	1860	852	25,309	16	13	4	22	5	45, 46	
Marion	Marion	1855	1860	959	17,237	30	23	4	21	8	55	
Marshall	Marysville	1855	1855	911	19,235	26	20	1	18	21	39, 40	
McPherson	McPherson	1867	1870	896	23,029	18	26	4	28	9	64	
Meade	Meade	1873	1885	979	5,207	83	86	5	35	31	122	
Miami	Paola	1855	1855	592	17,356	29	31	2	6	10	14	Lykins
Mitchell	Beloit	1867	1870	716	10,251	54	55	6	31	15	83	
Montgomery	Independence	1867	1869	649	48,390	6	5	3	12	14	26, 27	Wilson
Morris	Council Grove	1855	1858	707	9,192	61	54	4	21	8	56	Wise
Morton	Richfield	1866	1886	728	2,228	101	94	5	37	39	125	Kansas
Nemaha	Seneca	1855	1855	709	14,737	36	34	1	17	22	38	
Neosho	Erie	1855	1864	587	21,794	20	22	3	13	7	28	Dorn
Ness	Ness City	1867	1873	1,081	6,578	76	75	5	36	33	98	
Norton	Norton	1867	1872	880	8,693	63	61	6	40	17	101	Billings
Osage	Lyndon	1855	1859	721	13,117	40	29	4	15	35	32	
Osborne	Osborne	1867	1871	898	8,505	65	56	6	32	15	84	
Ottawa	Minneapolis	1860	1866	723	8,021	69	65	6	29	30	62	
Pawnee	Larned	1867	1872	755	8,560	64	69	5	36	33	91	
Phillips	Phillipsburg	1867	1872	906	10,370	53	58	6	40	17	87	
Pottawatomie	Westmoreland	1857	1857	854	12,530	41	39	1	17	36	41	
Pratt	Pratt	1867	1873	729	12,287	43	53	5	34	24	74	
Rawlins	Atwood	1873	1881	1,078	5,479	80	77	6	39	17	106	
Reno	Hutchinson	1867	1873	1,262	50,800	4	6	5	34	40	75,76	
Republic	Belleville	1860	1878	719	11,493	46	40	6	30	12	60	
Rice	Lyons	1867	1871	725	15,138	35	48	5	33	20	79	
Riley	Manhattan	1855	1855	626	22,132	19	30	1	19	21	42	
Rooks	Stockton	1867	1872	893	8,161	67	70	6	38	34	88	
Rush	La Crosse	1867	1874	724	7,337	71	73	5	36	33	90	
Russell	Russell	1867	1872	897	12,420	42	60	6	32	23	81	
Saline	Salina	1860	1860	720	32,347	10	14	6	29	30	63	
Scott	Scott City	1873	1886	724	4,183	90	96	5	37	32	113	
Sedgwick	Wichita	1867	1870	1,008	203,478	1	2	4	27	18	66, 67, 68	
Seward	Liberal	1873	1886	646	10,208	56	84	5	37	39	123	
Shawnee	Topeka	1855	1855	552	106,244	3	3	1	16	3	33, 34, 35	
Sheridan	Hoxie	1873	1880	893	4,683	86	87	6	39	34	103	
Sherman	Goodland	1873	1886	1,055	6,476	77	80	6	39	34	108	
Smith	Smith Center	1867	1872	893	9,131	62	50	6	40	15	86	
Stafford	St. John	1867	1879	795	9,242	60	59	5	33	20	77	
Stanton	Johnson	1873	1887	676	1,528	105	104	5	37	39	119	
Stevens	Hugoton	1873	1886	731	3,493	94	92	5	37	39	124	
Sumner	Wellington	1867	1871	1,187	24,262	17	12	5	26	25	69, 70	
Thomas	Colby	1873	1885	1,070	6,687	75	78	6	39	34	105	
Trego	Wakeeney	1867	1879	901	5,391	81	83	6	38	23	99	
Wabaunsee	Alma	1855	1859	795	8,061	68	62	4	19	35	44	Richardson
Wallace	Sharon Springs	1868	1888	911	2,203	102	99	6	39	23	110	
Washington	Washington	1855	1860	891	13,188	39	37	1	18	12	59	
Wichita	Leoti	1873	1886	724	2,200	103	102	5	37	32	111	
Wilson	Fredonia	1855	1865	574	16,434	32	27	3	13	7	29	
Woodson	Yates Center	1855	1855	504	7,010	73	72	4	14	37	30	
Wyandotte	Kansas City	1859	1859	159	167,198	2	1	2	4	29	7, 8, 9	

*Gill, 1904.
**Batschelet, 1942, pp. 105-113
†Ryan, 1948, p 82
††Ryan, 1948, p 135, Auto tag numbers indicate rank in population as of March 1, 1928
†††C=Congressional district; S=Senatorial district; J—Judicial district; SR—State Representative district. Ryan, 1948, pp. 126-134

Land Classification in Kansas

On May 20, 1785, Congress passed an act providing for the subdivision of the public lands of the United States excepting, however, the 13 original states, Texas, Kentucky, Tennessee, North and South Carolina, Georgia, and parts of Ohio. Furthermore, the act providing for the subdividing of the public lands by the system of rectangular surveying (sections, township, ranges) did not apply to the land north of the Ohio River and west of the Mississippi that was privately owned at the time the territory became a part of the United States (Raymond, 1914, p. 277, also appendix). The standard United States land unit adopted is an area 6 by 6 miles consisting of 36 square miles. This unit is designated a United States, Congressional, or government standard township. It is not to be confused with the organized, civil or municipal township which is a political unit and which always is designated by a name instead of by numbers. The civil township may be larger, smaller, or of the same size as the U. S. standard township. Each standard township is referred to two reference lines, a meridian and a parallel. In Kansas the reference meridian is known as the 6th Principal Meridian. It is a north-south line, longitude 97° 23′ west, passing through Wichita and Solomon. All standard land units are numbered, those east of this line are known as east ranges (R.) and those west as west ranges. The easternmost range in Kansas is Range 25 East (R. 25 E.), whereas the westernmost one is Range 43 West (R. 43 W.) (Fig. 8). Both limiting ranges constitute fractional units. The Kansas meridian also serves Nebraska, Colorado, Wyoming, and part of South Dakota (Fig. 9). All townships in the State are south townships and are referred for numbering to the 40th parallel which is the state line between Kansas and Nebraska and which also is used as the base line for land classification in Nebraska, Colorado, Wyoming, and a small part of South Dakota (Fig 9). There are 34 complete townships in Kansas. Township 35 South (T. 35 S.) which adjoins Oklahoma constitutes a fractional standard township as its north-south length is only 2½ miles instead of the required 6 miles.

Since the east and west boundaries of a standard township are meridian lines which converge when extended northward, townships normally diminish in size in that direction. In order to offset errors in area in the township, Calhoun, first surveyor-general in Kansas, was instructed to establish on the 6th Principal Meridian, standard parallels or east-west correction lines at intervals of every five townships or every 30 miles east to Missouri River or to the west boundary of the State of Missouri (U.S. Land Office, 1854, p. 38). Later

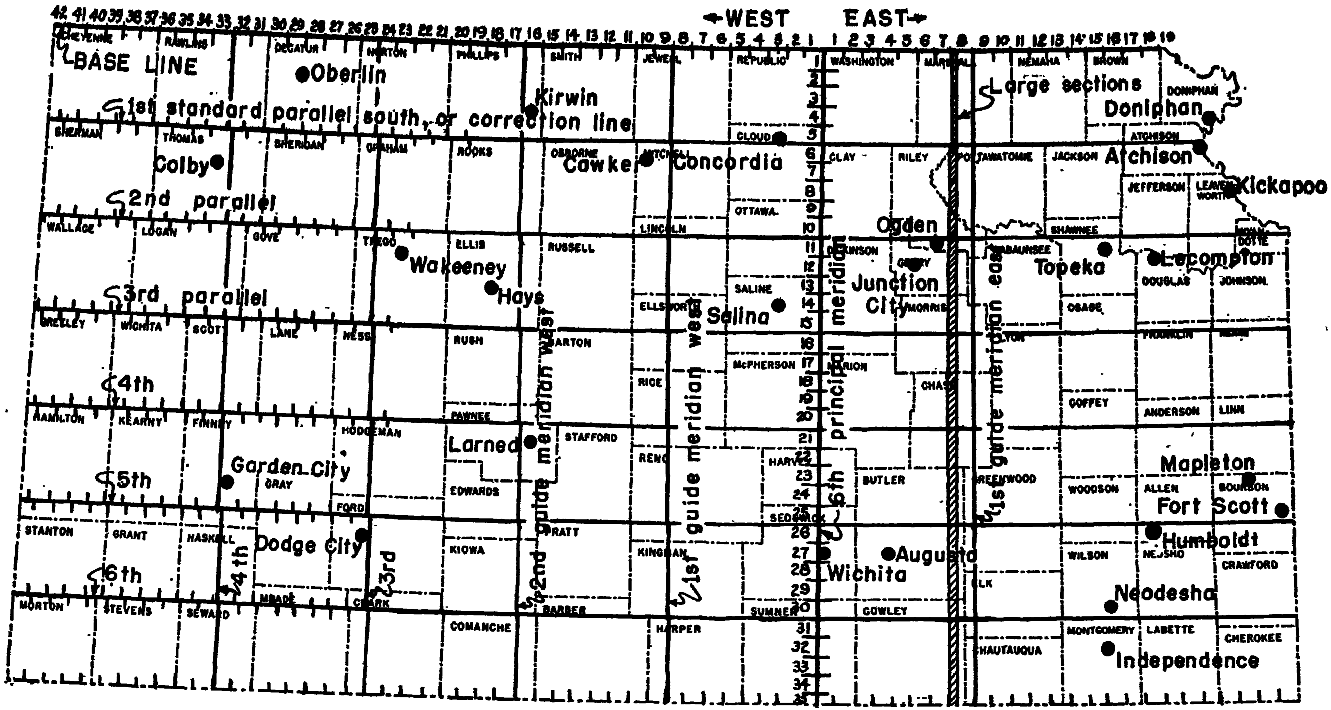


Fig. 8. Map of Kansas showing land classification base line, 6th Principal Meridian, standard parallels or correction lines, guide meridians, number of townships and ranges, strip of oversized sections in Range 8 East, and former U.S. Land Offices. (Figure 10 C shows numbering for these abnormally large sections in Range 8 East).

standard parallels were established west of the 6th Principal Meridian. There are six standard parallels or correction lines in Kansas (Fig. 8). Similarly, guide meridians spaced eight townships or 48 miles apart and extending in a north-south direction, are established in the state. There is one guide meridian east of the 6th Principal Meridian and five west (Fig. 8). In sectionized country, like Kansas, public roads usually follow the section lines. Wherever such

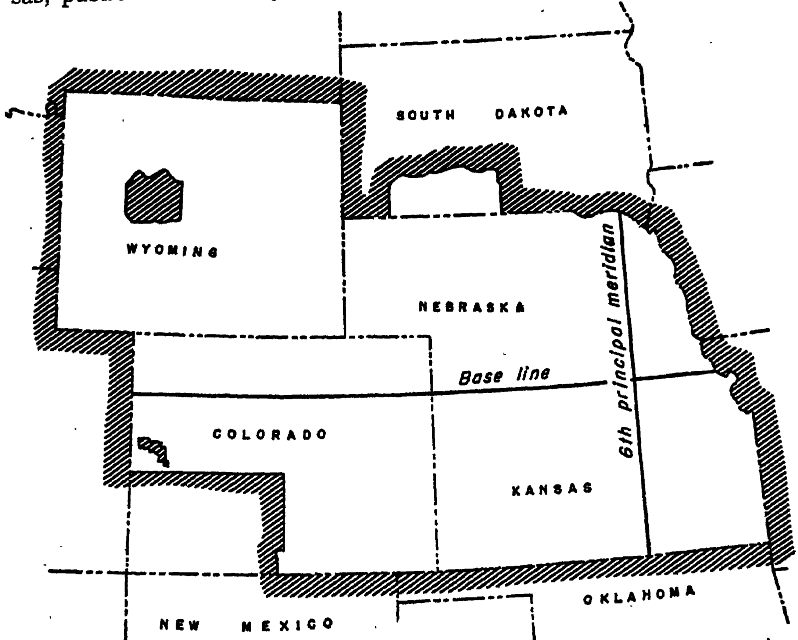


Fig. 9. Map showing base line and 6th Principal Meridian and the States governed thereby in land classification.

north-south section line roads cross the standard parallels or correction lines there is an offset or "jog" in the road.

The ideal U. S. standard township consists of 36 sections, each one of which is equal in area to one square mile or 640 acres. Sections are numbered, respectively, with section 1 in the northeast corner of the township, thence proceeding west and east alternately thru the township with progressive numbers until section 36 is reached in the southeast corner of the township (Fig. 10 A). The first public lands in the United States to be subdivided into standard townships are in the northwestern projection of West Virginia. They were surveyed in 1786. The first seven of these public land units were numbered by starting in the southeast corner of the township with num-

ber 1 and progressing upward or northward to section 6 in the right hand tier of sections. Section 7 constituted the basal section of the next tier of sections to the left with section 12 at the top. Similarly

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

A

36	30	24	18	12	6
35	29	23	17	11	5
34	28	22	16	10	4
33	27	21	15	9	3
32	26	20	14	8	2
31	25	19	13	7	1

B

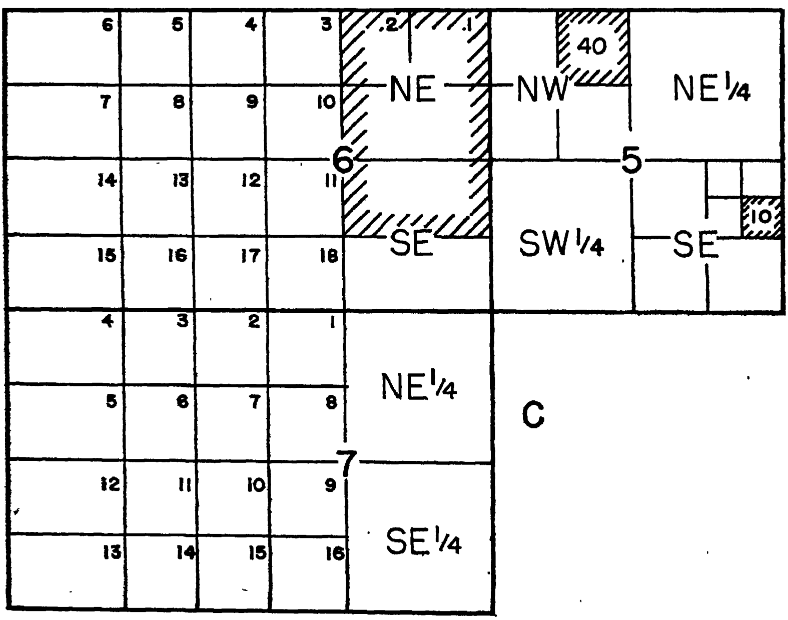


Fig. 10 (A)Conventional system of numbering sections of a township.
(B) Original numbering system in 1786.
(C) Sections 5, 6, and 7, T. S S., R. 8 E., Pottawatomie County, showing division of sections 6 and 7 into lots and systems of numbering of the abnormally oversized sections in Range 8 East. The number and area of lots vary in different counties. (Numbers 1 through 18 are lot numbers. Each lot in the western tier is more than 40 acres in area. Section 5 is of standard size, 1x1 mile).

sections 13, 19, 25, and 31 formed the basal sections in the remaining tier of sections (Fig. 10 B) (Johnson, 1907, p. 229 and fig. 99).

As stated elsewhere the convergence of meridians and errors in surveying are responsible for townships not being exactly 6 miles square. In surveying townships, measurements normally begin at the southeast corner and extend to the north and west. Accordingly, all errors in surveying are distributed in the northern and western tier of sections of each township, with the result that these sections contain a little more or a little less than 640 acres. In these sections all accumulated errors occur in the northern and westernmost "forties." A noted departure from the standard size of a section is found in the western tier of sections, sections 6, 7, 18, 19, 30, and 31 of Range 8 East throughout the entire north-south extent of the state. In sec. 7, T. 35 S., in the southernmost township in Cowley County and close to the Kansas-Oklahoma line, the east-west width of the section is 13,332 feet or 8,052 feet more than 1 mile. This section measures 1 x 2.525 miles and contains approximately 1,616 acres instead of the normal 640 acres. Other sections in the strip contain as much as 1,671 acres. The east-west width of the western tier of sections of the township of this range diminish progressively northward to the Kansas-Nebraska state line where in sec. 6, T. 1 S., in Marshall County and within a mile of the state line its width is 5,395.5 feet or only 115.5 feet more than the normal width of the average section. The cause of the abnormal east-west width of the sections and their consequent great variations in area is not clear. The unusual east-west width of the sections of this north-south strip has been explained (Newcomer, 1948, Bandy, 1948) as having been caused by two surveys which apparently started from opposite directions from their meridian base lines and which came together at this location. Since the excess land was insufficient for the forming of a new township the surveyor-general included the extra or excess land into the western tier of sections. The excessive size of the sections complicates legal description of land units within the section. Normally each standard section is divided into quarters, NE, NW, SW, and SE which in turn may be subdivided into smaller quarters and so on. Thus in Fig. 10 C the largest cross-hatched or 40 acre tract in section 5 is legally described as the NE¼ of the NW¼ of section 5, whereas the 10 acre cross-hatched area is the SE¼ of the NE¼ of the SE¼ of the section. Usually the words "of the" are omitted in the descriptions so that the above descriptions are written NE¼ NW¼ and SE¼ NE¼ SE½, sec. 5 respectively. In Range 8 East the excessive sections are divided as follows: the east quarters of these

sections are regular, one-half mile by one-half mile in area, and are known as the NE and SE quarters of the sections. The west part of the sections are divided into tracts or lots, the majority of which are 40 acres in area. In Butler County, however, the lots are 80 acres in area except along the west borders of the section where the lots are approximately 26 acres in size. The lots are designated as lot number 1, 2, etc. of the section. In Cowley County there are 32 lots (Gibson, 1948); in Butler County 18; whereas in Pottawatomie County there are 16 lots except in section 6 where there are 18 lots (Walker, 1948) (Fig. 10 C). To determine the actual size and location of the lots it is necessary to consult the Register of Deeds office in each county where the abnormal situation prevails and where the plats are on file (Williamson, 1948). A legal description of a tract of land outlined on the map, figure 10 C, by cross-hatching in sec. 6, T 7 S., R. 8 E., Shanon township, Pottawatomie County is: N½, SE¼ and S½, NE¼ and lots 1 and 2, sec. 6, T 7 S., R. 8 E.

The subdivision of Kansas into sections, townships, and ranges dates back to July 22, 1854 (Greene, 1904, p. 1), when Congress created the Territory of Kansas as a land district with provision for the location of a land office at the temporary seat of government. Before a land office could be put in operation, however, it was necessary to sectionize the country, for public surveys had to precede private entry. John Calhoun was commissioned the first surveyor-general of the Territory of Kansas and Nebraska on August 4, 1854, and also ex-officio register of filings for the land offices soon to be opened in them. Calhoun opened his first office in Wyandotte (Kansas City) soon after he was appointed surveyor-general. According to instructions to Calhoun (Johnson, 1902, p. 318 footnote) dated September 2, 1854, Congress established the 40th parallel or the Kansas-Nebraska State line as the principal base line from which to start the surveys both in Kansas and Nebraska. This reference or base line was astronomically established in 1854 by Captain T. L. Lee, topographical engineer, U. S. A. (Johnson, 1902, p. 319, footnote). In November 2, 1854, J. P. Johnson was given the contract to establish the base line, a survey which he started 16 days later and which he took 18 days to run.Johnson's work although paid for was not accepted (Johnson, 1902, p. 318, 320). The base line as originally surveyed extended for a distance of 108 miles west of Missouri River to the 6th Principal Meridian and was not extended farther west because of the "apprehensions of hostile interruptions from the Indians" (U. S. Land Office, 1854, p. 36). Furthermore, the 6th Principal Meridian was not actually established in the field at this

time. Calhoun's instructions from John Wilson, Commissioner, United States General Land Office, contained the statement that "at some future time, when necessary, it is proposed to start a Principal Meridian, extending on the north of such base line to the Missouri River in Nebraska, and on the south of the same to the southern boundary of Kansas, which is the 37th parallel of north latitude. Although the public surveys will count from the Principal Meridian precisely as if the same were surveyed, the labor of such meridian survey will now be omitted, and that labor will be directed to insure practical results of more immediate importance" (U. S. Land Office, 1854, p. 38). According to Calhoun's report to the Hon. Thos. A. Hendricks, Commissioner, United States General Land Office, dated October 20, 1856, the 6th Principal Meridian had been established south from the base line for a distance of 150 miles or to the Little Arkansas River near Valley Center north of Wichita in Sedgwick County (U. S. Land Office, 1856, p. 340). The report also stated that 1,864,141 acres had been surveyed and approved. The approved surveys comprised a strip of country extending along Missouri River to the Nebraska line and included most of Atchison, Brown, Doniphan, east half of Nemaha, a small corner of Jackson, a greater part of Jefferson, and all of Leavenworth and Wyandotte Counties, except the Indian and military reservations. Extensive surveys south of Kansas River had been completed in the field, but the office work was not finished at the time of Calhoun's report, and not a single township had been reported to the commissioner for approval.

In August, 1855, Lecompton was designated the territorial seat of government. The provision establishing the Territory of Kansas provided that the land office be located at the temporary seat of government. After Congress had appropriated $50,000 for a capitol building and it seemed likely that Lecompton would become the permanent capital of the State, Ely Moore, first commissioned register for Kansas, was ordered to erect a land-office building at the seat of government. The first filings were received at this office in May, 1865, although Calhoun, who acted as ex-officio register at Wyandotte previous to Moore's appointment as register, reported 3,036 preemption filings, many of which were the cause of much litigation (Greene, 1904, pp. 3-7). In June, 1857, Calhoun moved his Surveyor-general's office from Wyandotte to Lecompton. Since the establishment of the land office at Lecompton, Congress provided for land offices at 25 different places (Fig. 8), including Atchison, Augusta, Cawker City, Colby, Concordia, Dodge City, Doniphan, Fort Scott, Garden City, Hays City, Humboldt, Independence, Junc-

tion City, Kickapoo, Kirwin, Larned, Lecompton, Mapleton, Neodesha, Oberlin, Ogden, Salina, Topeka, Wakeeney, and Wichita. Of these land offices the ones at Lecompton, Doniphan, Fort Scott, Ogden, Augusta, Concordia, Cawker City, Hays City, Larned, Oberlin, and Garden City were original offices. As time went on the original land offices were moved to other locations, later to be consolidated with other land offices (Table 7). In 1905 the only land offices in Kansas were at Topeka, Wakeeney, Colby and Dodge City. Today there are no branches of the United States General Land Office in the State. Government plats for each county, however, are on file at the Register of Deeds office of each county, and all the plats together with the field notes may be consulted at the office of the State Auditor at Topeka.

Table 7. Kansas land offices, original locations, dates of establishment, and locations to which moved with dates

Original office Location	Date	Moved to Location	Date
Lecompton	8-1855	Topeka	9-1861
		Office closed	7-1-1925
Doniphan	3-1857	Kickapoo	12-3-1857
		Atchison	9-6-1861
		Topeka	12-1863
		Office closed	7-1-1925
Fort Scott	3-1857	Humboldt	9-3-1861
		Mapleton	10-3-1861
		Humboldt	5-15-1862
		Neodesha	12-15-1870
		Independence	10-3-1871
		Topeka	2-28-1889
		Office closed	7-1-1925
Ogden	3-1857	Junction City	10-6-1859
		Salina	5-1-1871
		Topeka	12-31-1893
		Office closed	7-1-1925
Augusta	6-11-1870	Wichita	2-20-1872
		Topeka	2-28-1889
		Office closed	7-1-1925
Concordia	7-7-1870	Topeka	2-28-1889
		Office closed	7-1-1925
Cawker City	6-1872	Kirwin	1-4-1875
		Oberlin	9-11-1893
		Colby	2-5-1894
		Dodge City	1909
		Topeka	1920
		Office closed	7-1-1925
Hays City	6-20-1874	Wakeeney	10-1879
		Colby	1905
		Dodge City	1909
		Topeka	1920
		Office closed	7-1-1925
Larned	6-20-1874	Garden City	1-25-1894
		Dodge City	2-10-1894
		Topeka	1920
		Office closed	7-1-1925
Oberlin	5-1881	Colby	2-5-1894
		Dodge City	1909
		Topeka	1920
		Office closed	7-1-1925
Garden City	5-1883	Dodge City	2-5-1894
		Topeka	1920
		Office closed	7-1-1925

Time Belts

Because of the eastward rotation of the earth there is a difference in time of 4 minutes for each degree or an hour for each 15 degrees of longitude. When it is noon at Greenwich, England, 0 degrees longitude, it is 7 a.m. at Philadelphia, Pennsylvania, 75 degrees west longitude; 6 a.m. at St. Louis, Missouri, 90 degrees west longitude; and 5 a.m. at Denver, Colorado, 105 degrees west longitude (Table 8). Since Kansas is about 7½ degrees wide longitudinally there is a difference of approximately 30 minutes between sun rises on its east and west borders. Previous to 1883, most towns in the United States used the local time of the meridian passing through their respective towns. The introduction of the railroads, telephone, and telegraph as well as the need for standardized time for scientific purposes led to the adoption of a standard system of time belts in 1883 (Johnson, 1907, p.65). For purposes of time the United State is divided into the Eastern, Central, Mountain and Pacific standard time belts (Table 8). The time of these four belts is respectively the mean solar time of the 75th, 90th, 105th and 120th meridians. Kansas is divided on the basis of time into the Central Standard Time and Mountain Standard Time belts (Fig. 11). Most of Kansas is in the Central Standard Time belt and uses the mean solar time of the 90th meridian which passes through St. Louis, Missouri. When it is noon at St. Louis it is also noon at Kansas City, although actually it is only 41½ minutes after 11 o'clock by the sun. Similarly, it is also noon at Wichita, Dodge City, and Elkhart although their respective sun times are 11:30, 11:20, and 11:12½ a.m.

The dividing line between Central Standard Time and Mountain Standard Time belts in Kansas is irregular and as far as is known is unofficial. Maps showing the time belts in the State are not in agreement as to boundaries (Fig. 11). Furthermore, the various railroads extending westward through the State use their own points

Table 8. Relation of Longitude to Time and U.S. Time Belts

Longitude		Time U.S.	Time Belt
Greenwich, England	0	Noon	
	15	11 a.m.	
	30	10	
	45	9	
	60	8	
Philadelphia, Pa.	75	7	Eastern Standard
St. Louis, Mo.	90	6	Central Standard
Denver, Colo.	105	5	Mountain Standard
East boundary, Calif	120	4	Pacific Standard

of changing time (Table 9). These points are the divisional points of railroads where, as a rule, new train crews take over the trains. Where a branch line of a railroad, however, terminates within the State, as for example, the branch line of Atchison, Topeka & Santa

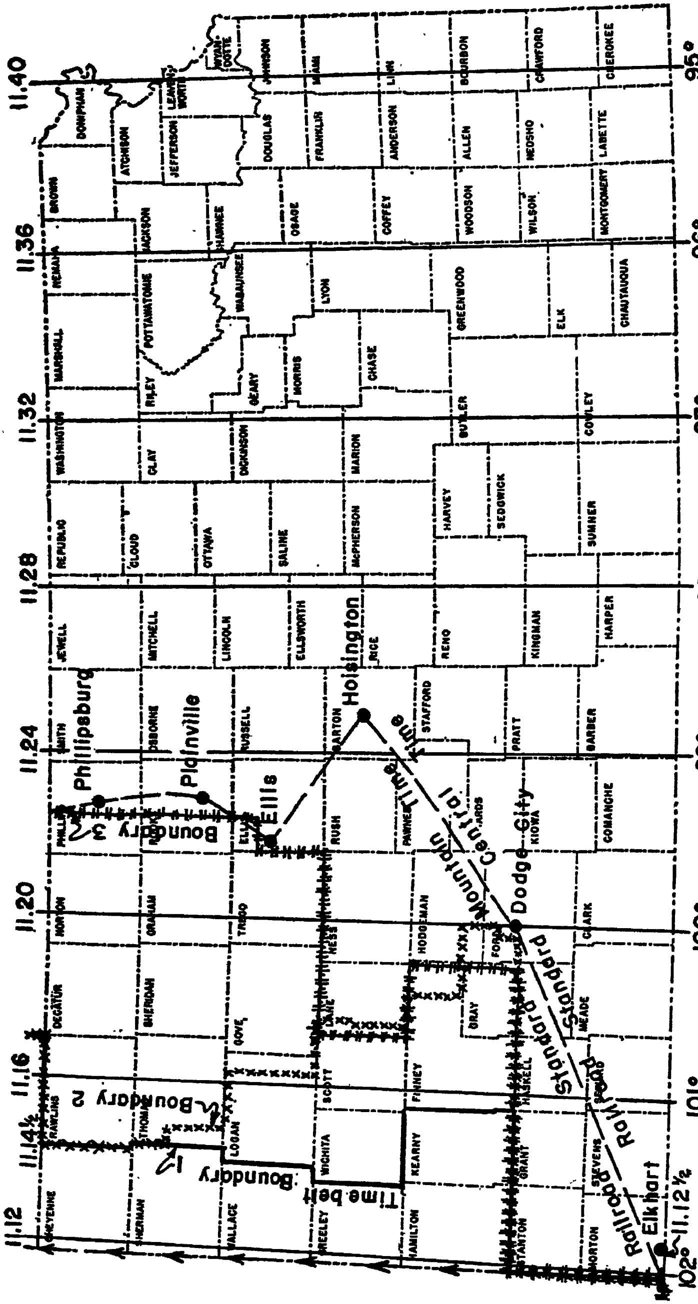


Fig. 11. Map of Kansas showing time belts, divisional points of railroads where time is changed from Central Standard to Mountain Time, and solar or sun time in the State when it is noon, Central Standard time or 12 o'clock noon solar time at St. Louis, Missouri. Note that there is a difference of 29 minutes in sun time between Kansas City and Elkhart in the southwest corner of the State. Both cities, however, use the same time which is the mean solar time of the 90th meridian at St. Louis, Missouri. The arrows along the western boundary indicate suggested northward extension of the time belt boundary.

Fe from Dodge City to Elkhart in the southwest corner of Morton County, the time change is not made. Cities, too, do not always use the same time as do the railroads as is well illustrated by Dodge City. The Atchison, Topeka & Santa Fe railroad changes from Central to Mountain Standard time at Dodge City; the city, however, uses Central Standard time. The same condition prevails at Hoisington in Barton County, at Phillipsburg, Phillips County, and at Ellis in Ellis County.

The irregularity in the line separating the Central Standard from the Mountain Standard Time belts in Kansas and the fact that this line has been changed several times in the past is best explained on the basis of convenience to and desires of the various towns and cities choosing their time belts. Residents of Western

Table 9. Divisional Points of Railroads where changes from Central to Mountain Standard Time are made.

Railroad	City	County
Chicago, Rock Island & Pacific	Phillipsburg	Phillips
Union Pacific	Plainville	Rooks
Union Pacific	Ellis	Ellis
Missouri Pacific	Hoisington	Barton
Atchison, Topeka & Santa Fe	Dodge City	Ford

Kansas towns prefer to use Central Standard Time or the "fast time" as they term it because it gives them longer sun hours, the equivalent of sun-light saving time. On a purely longitudinal basis the line separating the two time belts should be at longitude 97° 30′, a meridian passing through Halstead in Harvey County. For practical purposes in Kansas the line might well be at the 6th Principal Meridian whose longitude is 97° 23′ and whose position in sun time is only one-half of a minute earlier than solar time at 97°30′. Since the 97° 30′ or 97° 23′, (6th Principal Meridian) longitude lines do not constitute the division line between the two time belts in the State, it is suggested here that it be located at the Kansas-Colorado State line for the following reasons: (1). Except for the railroads, people traveling across country westward through the State or eastward from Colorado into Kansas are unaware of the places where the time changes take place and consequently may be inconvenienced because of it.

(2). All people traveling across the state line are aware of their either leaving Kansas or entering it because of the highway markers indicating this fact. An additional word advising change of one's watch to one hour earlier or later as the case may be could easily be added to the signs.

(3). The southernmost 50 miles of the dividing line between the

two time belts, the west borders of Morton and Stanton Counties, coincide with the Kansas-Colorado state line. It is therefore not unreasonable and illogical to continue the northward extension of the dividing line between the two time belts.

(4). Placing the dividing line between the two belts at the Kansas-Colorado state line would put all of Kansas in one time belt. There is at present less than a difference of two minutes of solar time between the northermost point in Kansas on the dividing line between the two time belts and the Kansas-Colorado state line, certainly an insignificant difference in time.

(5). By making the Kansas-Colorado state line the west limit of the Central Standard Time belt in Kansas, the limiting line would become a straight line which mathematically and according to sun time it should be.

(6). At present when it is noon at Elkhart in the southwest corner of the State in Morton County it is 11 o'clock at the following cities to the north and all east of Elkhart: Syracuse in Hamilton County, Lakin in Kearney County, Tribune in Greeley County, Sharon Springs in Wallace County, Goodland in Sherman County, and St. Francis in Cheyenne County. Such a condition is not only confusing but is without logical support.

It is further suggested that the dividing line between Central and Mountain Standard Time belts in Kansas be officially established by the State Legislature in order to avoid possible litigation which might arise because of time considerations such as are involved in fire and other insurance policies and other legal matters.

Time belts and differences in solar time between Kansas towns are shown in Figure 11.

Naming The State

Kansas was named for the Kansas River which in turn derived its name from the dominant tribe of Indians living in the State when first visited by white men (Andreas, 1883, p. 33). According to Isley and Richards (1941, p. 83) the State was named by Stephen A. Douglas, United States Senator from Illinois and author of the Kansas-Nebraska bill. The name Kansas was suggested to Douglas by Senator David R. Atchison of Missouri. Nebraska had just been named for Nebraska River or the Platte, the Indian name for the river. Therefore it seemed logical to name the other Territory "Kansas" for its chief river. Like many Indian names, Kansas has had numerous forms of spelling, chief among which are: Kanzas, Kansies, Kanzon, Konza, Konzas, Kasas, Kanzan, Kanzans, Canceas,

Cansez, Canzas, Canzes, Canses, and Canzon (Andreas, 1883, p. 33).

In pre-and early Territorial days the common form of spelling Kansas was Kanzas. Edward E. Hale of Worchester, Massachusetts, author of "The Man without a Country" was an ardent advocate of the original spelling. In his book "Kanzas and Nebraska" published in 1854 and written for the purpose of assisting in selling Kansas to the people of the United States he states (p.v.) "... I have held to the spelling Kanzas, of most of the travelers and of the Indian department, in preference to Kansas, the more fashionable spelling of a few weeks past. There is no doubt that the *z* best expresses the sound, that it has been almost universally used till lately, and that it is still used by those most familiar with the tribe and the river which have, time immemorial, borne this name. Kanzas, too, will soon be a State. Its name then will, at best, too much resemble the name of Arkansas, which was, in fact, derived from it. To keep them by one letter more apart is to gain something". Kansas River and the Kansas Indian tribe were also known by early French settlers as the Kau, or Kaws, names which are contractions of the above listed names. According to Andreas (1883, p. 33), in the language of the Kansas Indian tribe, Kansas means "smoky" a term perpetuated in the south fork of Kansas River, the Smoky Hill River. Wedel (1946, pp. 3-4), however, citing Dorsey and Morehouse (1908, pp. 332-336) states that the name *Kansa* or its 125 different ways of spelling " ' refers to winds,' or wind people, but that is exact meaning is not known" and that the name has no reference whatsoever to "smoky" as stated by Andreas. Morehouse also contends that the name *Kansa* is neither of Indian or French origin, but that it probably was derived from the Spanish verb *cansar,* which means to molest or to harass and from *cansando* which signifies a troublesome fellow.

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The Editor's Page

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ROBERT TAFT, *Editor*

DR. WALTER H. SCHOEWE

Dr. Walter H. Schoewe, whose article on Kansas geography is featured in the current issue of the *Transactions*, scarcely needs an introduction to members of the Academy. Since 1925 he has been an Academy member and has taken a very active part in its affairs. He has been vice president, president (in 1938), and is now associate editor of these *Transactions* and chairman of the Academy committee on conservation. He has also contributed many times to the pages of this journal.

Dr. Schoewe is a native of Wisconsin and received his undergraduate training at the University of Wisconsin. His doctorate was received from the University of Iowa. He has taught at Iowa, at the Colorado School of Mines, and at the University of Kansas where he has been a member of the staff since 1920.

Not only has Dr. Schoewe contributed to our knowledge of the geology and geography of Kansas but he has been equally active in popularizing this knowledge. He is frequently in demand for his lectures on "Scenic Kansas" on "Precious Stones and Minerals" and on "The Mineral Resources of Kansas." The Academy is fortunate in possessing such a loyal and productive member.

* * *

Recently the editor visited at some length with one of his friends from a denominational college of the state. The friend had recently attended a meeting of a number of administrators of Kansas colleges. Among the

topics discussed at the administrators' meeting was the ever-present problem of teachers' salaries and the questions presented by rising salary scales as related to college budgets. In the course of the discussion, one leader stated in effect "We are paying our new—and young—teachers salaries that enable us to compete with other schools. Older faculty members will be continued at essentially the salaries they have drawn in the past. Even though many of them could obtain considerably larger salaries elsewhere, few will leave. They have bought property, have become so thoroughly rooted and so attached to us that there is little danger of our losing them."

This unjust and callous policy was announced not by the head of a state-supported school—godless and soul-less schools, our critics sometimes call us—but by a reverend gentleman, the head of a denominational college in the state. Although there is no doubt that a grave financial problem confronts all of our schools, a problem arising from rapidly increasing costs of education on every score, no far-sighted solution will solve the problem successfully that does so at the expense of the older teacher. College and university salaries, as the editor has had occasion to remark before in these columns, were inadequate before the war and they continue to be inadequate. When one considers the average salaries of the highly trained college and university teacher in relation to salaries and incomes of professional men and women in general, little other argument on this point is necessary; that is, no other argument is necessary if one is willing to concede that the profession of college and university teaching and research is as necessary in the American way of life as are professions which protect the health of our citizens, which protect our interests before the bar, or which design, construct, and maintain our complex industries and related activities.

That the policy of discriminating against the older teacher, however—to return to our present complaint—is unfair and may result eventually not only in a personal but an institutional demoralization, has been recognized by others better qualified to judge than the editor. We can, for example, quote from the now well-known report of the President's Commission on Higher Education. This document and the specific statement quoted below take on added significance within the state when it is recalled that Kansas had a representative on this Commission, our own President Eisenhower of the Kansas State College. Lest the problem of the older teacher be too readily dismissed by college administrators within the state—each of whom will receive a copy of this editorial—let us repeat what the Commission has to say on the point at issue. The report states:

Because of limited resources some colleges and universities in 1946-47 and 1947-48 were adopting the dangerous expedient of holding increases in professors' salaries to a pittance while increasing

instructors' by 35 and 40 per cent. The increases for instructors were not too large; those for the professors were much too small. The competent, experienced faculty member, who follows the traditional pattern of standing by his institution and waiting for salary increments and rewards, should not be penalized because he does not sell his services each year in a competitive market; if he is so penalized, the professional morale of the entire faculty may be undermined. Salary policies in individual institutions should be determined with the participation of faculty representatives. The policies should be clear-cut and understood by all. They should fix the minimum for each rank but have wide flexibility as to maximum salary and should provide for complete freedom of decision for exceptional cases.—Higher Education for American Democracy, vol. 4 (1947).

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

In this issue of the *Transactions* (page 355) we publish again, after a lapse of several years, the complete membership list of the Academy. Will you please turn to the list and see if we have your name, professional connection, and address properly listed? If errors have occurred, especially errors of address, please advise the managing editor, Dr. W. J. Baumgartner, University of Kansas, Lawrence, so that there will be no delay in having the issues of the *Transactions* reach you promptly. If, by chance, no star appears on your name, your two dollar membership and subscription fee should be hurriedly mailed to the treasurer, Mr. Standlee V. Dalton, Fort Hays State College, Hays, Kansas.

Climate of Kansas by S. D. Flora is a recent noteworthy addition to the scientific literature on Kansas. This 320 page book has just been published as a report of the Kansas State Board of Agriculture. Although primarily a tabulation of climatological data based on U.S. weather bureau records from the early 1890's up to 1945, discussions and reviews of data have been made by Mr. Flora on such topics as dry periods, dust storms, rainfall, snowfall, temperatures, frost, floods, winds and tornadoes, relative humidity, and sunshine. In addition to the very extensive tables, data have also been presented graphically and by the use of numerous maps. The volume also includes three special articles "Climate

Insects" by Dr. R. C. Smith, "Crop Production and Climate" by Dr. H. H. Laude, and "Temperature and Water Supplies" by Mr. George S. Knapp.

Copies of this valuable compilation may be secured by addressing Mr. J. C. Mohler, Secretary, State Board of Agriculture, Topeka.

Dr. Ralph E. Silker becomes head of the department of chemistry at Kansas State College, Manhattan, succeeding Dr. H. H. King, retired. Dr. Silker is a graduate of the University of Dubuque and received his doctorate at the University of Iowa in 1934. He was a member of the chemistry department staff at Manhattan from 1941 to 1945 and since the latter date has been director of research of the J. W. Small Company of Kansas City, an extensive producer of dehydrated alfalfa. Dr. Silker also has had teaching experience at Doane College and at Nebraska State Teachers College, Chadron.

In addition to the appointment of Dr. Silker, other changes in the department of chemistry at Kansas State include appointments of Dr. Robert E. Clegg, associate professor, Dr. Donald Kundiger, assistant professor, and Dr. C. H. Whitnah as associate professor. Dr. Clegg will fill the position of poultry chemist formerly held by Dr. Ralph E. Conrad. He is a graduate of Rhode Island State College in 1936 and received his doctorate from Iowa State College in 1948. Dr. Kundiger, who received his doctorate from the University of Wisconsin in 1942, will teach and direct research in organic chemistry. For the past several years he has been on the staff of the Rohm and Haas Company, Philadelphia. Dr. Whitnah, formerly dairy chemist at the College, returns to that position after three years spent in the U.S. army as nutrition expert and two years' work on the research staff of the University of Denver.

Dr. A. B. Leonard, associate professor of zoology, University of Kansas, and a member of the executive council of the Academy, is on leave during the school year of 1948-49. During the fall, Dr. Leonard will be doing field work in the Ozarks but after Christmas his leave will be spent in the Museum of Comparative Anatomy, Harvard University.

Dr. Emil O. Deere retires from his position as dean of the college, Bethany College, Lindsborg, beginning with the present school year but will continue his duties as professor of biology and geology and director of the veterans program. Dr. Deere will be succeeded as dean by Dr. J. L. Hermanson who will also serve as professor of chemistry. Dr. Hermanson was formerly a member of the Bethany College staff but from 1944 to 1948, he was professor of chemistry at Gustavus Adolphus College, St. Peter, Minnesota.

Dr. Daniel S. Ling, who received his doctorate from the University of Michigan this past summer, joins the staff of the physics department, University of Kansas, beginning with the fall semester. Also added to the physics department staff will be

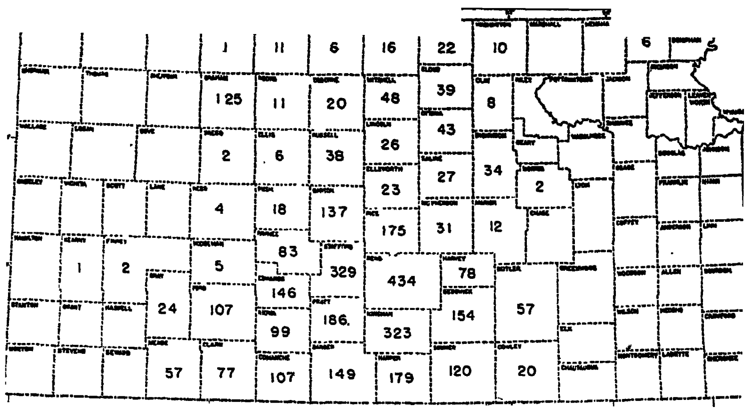
Ralph W. Krone, instructor. Mr. Krone is completing his requirements for the doctorate at Johns Hopkins University, Baltimore.

Readers of the *Transactions* will be indebted to Mr. Fred J. Sykes, state conservationist, U. S. Soil Conservation Service, Salina, Kansas, for the map of the shelterbelt plantings made in Kansas by the U.S. Forest Service during the years 1935-1942 inclusive, which is given below. Mr. Sykes has also prepared the following brief report on shelterbelt activities in Kansas since 1942. Mr. Sykes writes:

On July 1, 1942, all funds were gone from the Forest Service for shelter-belt activities, and the responsibility was transferred to the Soil Conservation Service at that time, without additional funds to continue this activity. The planting of farmstead windbreaks and field windbreaks, however, is a part of the soil conservation program, and is being continued as a regular practice where needed and where acceptable to the farmer.

Since 1942, 349 miles, covering 3,661 acres of tree belts, have been planted around farmsteads and along field borders. I can fully appreciate that this does not compare with the amount of plantings made by the Forest Service; however, in the plantings made since 1942, by farmers cooperating with the Soil Conservation Service, only half of the planting stock is furnished by the Soil Conservation Service, and the farmers have prepared the planting sites, planted the trees, and maintained them.

We made a survey of shelterbelt and windbreak plantings in 1946, and found that 92 per cent of these plantings were satisfactory, and 8 per cent not satisfactory. One of the limiting factors in the expansion of shelterbelts during the past six years has been the shortage of available, adapted planting stock — and available labor and equipment for planting and maintaining shelterbelts. It is my opinion that as these conditions improve, the planting of trees in Kansas will



Farm shelterbelt plantings in Kansas 1935-1942. Numbers show linear miles of shelterbelts by counties; each shelterbelt ordinarily consists of seven to ten rows of different species.

increase materially; however, I do not expect it to reach the proportions which were attained by the Forest Service, during the period 1935-1942, inclusive, when site preparation, planting, and maintenance was done by the Government.

Dr. Henry S. Fitch, Dr. Frank Peabody, and Dr. Rollin H. Baker have been appointed instructors in zoology at the University of Kansas. Dr. Fitch, who received his doctorate from the University of California in 1937, has been for the past eleven years ecologist for the U.S. Fish and Wildlife Service. He will teach undergraduate and graduate courses in ecology and will also supervise a study of animal life in relation to the natural grasses and trees on the hilly, wooded portions of the university-owned Robinson farm north of Lawrence.

Dr. Baker, who received his doctorate from the University of California this past June, is a specialist in the propagation and conservation of game birds and fur-bearing animals. In addition to teaching, he will be assistant curator of mammals in the museum of natural history. Dr. Peabody, also a graduate of the University of California, will teach a course in "Animals of the Past" and assist in courses in comparative anatomy.

Dr. Fitch and Dr. Baker, together with Dr. E. R. Hall, director of the museum of natural history, will form the nucleus of a staff for an expanded research program at the University in the propagation and conservation of economically valuable wildlife.

Dr. Henry T. Ward has been appointed head of the department of chemical engineering at Kansas State College, Manhattan. Dr. Ward is a graduate of the Universities of Michigan and Wyoming, receiving his doctorate from the University of Michigan in 1931. He has taught at the University of Wyoming, Montana State College, and Drexel Institute of Technology, Philadelphia. In 1947, he became head of the department of chemical engineering at the University of Arkansas.

Dr. Charles D. Michener, formerly assistant curator of lepidoptera, American Museum of Natural History, New York City, becomes associate professor of entomology in the University of Kansas. Dr. Michener received his doctorate from the University of California in 1941 and during a stay in the U.S. Army carried out an investigation on chiggers, an insect only too well-known to Kansans.

Among the retirements recently announced at the University of Kansas were included the names of Dr. H. E. Jordan, for 37 years a member of the mathematics department, and Dr. H. H. Lane, for 26 years professor of zoology. Dr. Lane's extended series of articles on the fossil vertebrates of Kansas has made his name well known to all readers of the *Transactions*.

In *Our Plundered Planet* (Little, Brown, 1948, $2.50) Fairfield Osborn, president of the New York Zoological Society, gives an informative discussion

of man's mistreatment of the good earth. The discussion involves three major facts: the interrelations and interdependence of all forms of life and their inescapable dependence upon the natural resources of the earth; the vast increase of technical competence and consequently of man's ability to despoil the natural resources; and the veritably prodigious increase of the human population of the world and the resulting increase of pressure on the food supply and on other earth products. The portentious implications of these three facts are impressively described. Appropriately, the book is dedicated "To all who care about tomorrow." As tomorrow is not far away, those who care about it—as we all should—may benefit from reading what the author has to say.—F. D. Farrell.

We regret deeply to report the tragic death of Dr. John W. Greene, professor of chemical engineering at the University of Denver, and a former member of the Academy. Dr. Greene, onetime member of the staff of Kansas State College, Manhattan, was one of four persons drowned on a fishing excursion in the South Platte River near Denver, on May 22. Dr. Greene was professor of chemical engineering at Kansas State from 1937 until 1946.

The construction of the proposed chemical plant of the Stanolind Oil and Gas Company at Garden City has been indefinitely postponed. Rapidly mounting costs of construction are reported as the cause of the postponement.

The U. S. Bureau of Mines recently reported a 20 per cent decrease in zinc production during 1947 as compared to 1946 in the tri-state area (Kansas-Missouri-Oklahoma). Lead mining and exploration in the above three states and Arkansas were stimulated to a high level because of increasing lead prices but the total output during 1947 was three per cent less than in 1946. The decrease resulted from the declining grade of ore and the need for extended development work necessary to replenish ore reserves drawn upon during the war. The production of lead and zinc reported for Kansas during 1946 and 1947 is given as follows:

	1946	1947
Lead	6,445 short tons	7,285 short tons
Value	$ 1,405,010	$2,098,080
Zinc	47,703 short tons	41,497 short tons
Value	$11,639,532	$9,544,310

Representatives of Lambda Delta Lambda, national honorary society for physical science students met on the campus of Kansas State Teachers College, Emporia, during the week end of June 18 for their biannual convention. The meeting was the first national convention since the war.

Dr. Mary T. Harman, professor of zoology, and Dr. H. W. Brubaker, professor of chemistry at Kansas State College, Manhattan, were among five emeritus faculty members honored by special recognition at the alumni dinner at Manhattan on May 29th. Dr. Harman has been a member of the Kansas State staff for 36 years and Dr. Brubaker for 35 years.

More than twenty members of the State Geological Survey were active during the past summer in various parts of the state. Their activities included:

A county mapping project which was begun last summer. Field work in Chase and Lyon Counties was completed . and work was started in a third eastern Kansas county. Geologists taking part in the project included Dr. J. M. Jewett, Howard O'Connor, William Connor, Raymond Mann, and James Keller.

Ground-water studies, under the direction of V. C. Fishel, were carried on throughout the State. Investigations of ground-water resources were completed in Wichita and Greeley Counties by John Branch and in Jewell County by A. R. Leonard. Glenn Prescott began a study in Lane County and Delmar Berry initiated one in Lincoln County. Shallow-water supplies were investigated in southeastern Kansas, primarily in connection with the dairy industry in Labette, Cherokee, Crawford, and Neosho Counties. Wallace B. Howe, Charles K. Bayne, and Prescott took part in this project. Kenneth Walters supervised test drilling for the availability of ground water resources in the glaciated part of northeastern Kansas.

Dr. John C. Frye, Norman Plummer, and W. B. Hladik studied the loess deposits in the northern one-third of the State, paying particular attention to the ceramic characteristics of these near-surface silts and clays. Plummer and Sheldon Carey sought new ceramic uses for volcanic ash, of which there are many deposits in central and western Kansas. Survey ceramists are doing experimental work in the manufacture of lightweight aggregate from Kansas shales, and will continue to study Kansas clays for use as refractories.

Dr. W. H. Schoewe completed field work on the central Kansas lignites and soft coals, which he is investigating to determine their possible commercial uses. A chemical study of Kansas coals is in progress.

Under the direction of Russell Runnels and Albert Reed, chemical studies of the industrial minerals and rocks of the Kansas River Valley was made. By the use of the spectrograph, they were able to make more complete analyses than has been possible in the past. They also conducted a study of the vanadium content of units of northern Kansas silts and siltstones. Vanadium is presumably a harmful ingredient of clays. Runnels will continue his investigation of the phosphate content of eastern Kansas shales for agricultural uses.

Dr. Jewett also gathered oil data, studying secondary oil recovery possibilities, with particular emphasis upon water flooding and investigating oil geology for deeper drilling in eastern Kansas.

W. B. Howe was also employed in oil scouting in southeastern Kansas, collecting coal and clay samples, and investigated the stratigraphy of the Cherokee coal beds. He also rendered assistance on geologic problems from the Pittsburg divisional office.

Earl K. Nixon finished a review and summary of raw materials for a mineral industries map and a petroleum map of the state. Topographic mapping continued along the Kansas River Valley and in southeastern Kansas.

Publications of the State Geological Survey issued since the June number of the *Transactions* was released include:

Bulletin 72 *Upper Cambrian and Lower Ordovician Rocks in Kansas,* Raymond Keroher and Jewell Kirby; 140 pages; 25 cents.

Bulletin 76, part 4, *The Manufacture of Ceramic Railroad Ballast and Constructional Aggregate from Kansas Clays and Silts,* Norman Plummer and W. B. Hladik, 60 pages, 10 cents.

Bulletin 76, part 5,*Radioactivity Surveys in the Kansas Part of the Tri-State Zinc and Lead Mining District, Cherokee County, Kansas,* Robert M. Dreyer, 8 pages, 10 cents.

Copies of the above bulletins may be secured without charge at the State Geological Survey offices, University of Kansas, Lawrence, or they may be obtained for the mailing charges indicated above by addressing the Survey.

The Magnolia Petroleum Company recently announced that a new natural gasoline and liquefied petroleum gas plant will be constructed in Grant County, Kansas. The plant will handle 100 million cubic feet of gas per day and it is expected that the plant will recover 17% of the propane in the gas. The residual gas has been contracted for by the Cities Service Company. Gas for the operations of the plant will come from approximately 160 wells in the west Hugoton field of Kansas, one-third of which have already been drilled by the Magnolia Company. The project is expected to be complete by spring.

Kansas State Board of Agriculture, by Edwin O. Stene, is a 76 page booklet describing the history, functions and organization of this important state board. Primarily a study in Kansas administrative history, it contains general information on certain aspects of Kansas agriculture and government of interest to all. The booklet, just released, may be secured by addressing the Director, Bureau of Government Research, Strong Annex F, University of Kansas, Lawrence.

The Colorado Museum of Natural History, Denver, has recently published a most interesting book *Birds of Arctic Alaska* by Alfred M. Bailey. In addition to the topic indicated by the title, the book contains within its 318 pages, a narrative of the author's field work done in 1920-29 (89 pages); an account of the vegetation of the history of observations and collection of the birds of Arctic Alaska (9 pages); the technical description of the birds, which includes the greater bulk of the volume (172 pages); a bibliography of 5 pages; and last but not least some 100 illustrations, chiefly photographs. Among the later are many excellent pictures of fauna, flora,

landscape, and life of far northern regions.

Although the field trips upon which much of the work is based were made many years ago, the technical report on birds has been brought up to date by the inclusion of collections made by the author's friends and associates and by a study of the published literature. Not only is the volume a contribution to the field of ornithology but in its content there will be found general information on a region of great military importance in the defense of our country.

Copies of the book may be purchased directly from the Museum (City Park, Denver 6) at \$4.60 (cloth bound) or \$3.10 (paper bound).

• • •

The qualities the individual faculty member should possess include sound scholarship, professional competence, a clear concept of the role of higher education in society, broad humanistic understanding, lively curiosity, a sincere interest in research, insight into motivation, and a sympathetic, intelligent understanding of young people.

No matter what may be the primary function of the faculty member, he should possess these qualities. In addition, a teacher must know how to make his subject matter alive and understandable to others and to give to students something of his own broad concept of its content and its relationship to other branches of knowledge. Further, he should be able to guide research and to counsel students.

The researcher has a responsibility to teach by example and to create the atmosphere in which intellectual curiosity may thrive.

The administrator's role is to make it possible for staff members to function in a smoothly run organization. He sets an example of how the tools of management contribute to organization, and offers leadership and opportunity to the faculty in its continuing efforts to do better work.

Those who offer special services should always recognize that their function is that of supplying the basic professional assistance which facilitates the operation of the educational process. Collectively the faculty must realize their intellectual and social interdependence.

—*Report of the President's Commission on Higher Education, vol. IV,* 1947.

Two Races of Elgaria kingii Gray.

J. A. TIHEN, Harper, Kansas

Recent examination of specimens of *Elgaria kingii** from New Mexico, Arizona and Chihuahua has led to the conclusion that two subspecies are recognizable. The following notes are based on a total of sixty-five specimens from the following collections: Carnegie Museum, Cornell University, American Museum of Natural History, Museum of Comparative Zoology, University of Kansas, University of Rochester, United States National Museum, and the collection of Dr. Edward H. Taylor. I am deeply indebted to the persons in charge of these various collections for making the material available to me for study.

Elgaria kingii kingii Gray

Elgaria Kingii Gray, 1838, Ann. Mag. Nat. Hist., ser. 1, vol. 1: 390.

Gerrhonotus multifasciatus Duméril and Bibron, 1839, Erp. Gen., vol. 5: 401.

Gerrhonotus Kingii, Bocourt, 1871, Nouv. Arch. Mus., vol. 7, Bull.: 106.

Type:—A specimen in the British Museum; type locality, Mexico (*fide* Boulenger, 1885).

Range:—Central and southern Chihuahua, intergrading with *E. k. nobilis* in the northwestern part of that state.

Diagnosis:—An *Elgaria* of the *kingii* group with 50-56 transverse rows of dorsals; uppermost primary temporal in contact with the uppermost secondary temporal.

Remarks:—The applicability of the name *kingii* to the Chihuahuan race seems fairly well established, although the exact provenance of the type is not certain. The type specimen was collected by Thomas Bell; another of Bell's specimens was described by Duméril and Bibron and figured by Bocourt (1878, pl. 21C, figs. 2-2a). Boulenger and Duméril and Bibron both give fifty as the number of transverse dorsal scale rows; even considering the possibility that the counts were not made as mine were (occiput to posterior border of thigh), this count is more consistent with the southern than with the northern race. Bocourt's figure shows the uppermost primary temporal in contact with the uppermost secondary, as is typical of the Chihuahuan form.

I have seen eight specimens referable to this form, five from

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*The use of the generic name *Elgaria* for this form is in conformity with the author's revision of the genera of gerrhonotine lizards. (Amer. Midl. Nat., in press).

Mojárachic (EHT 18982, 23026-23029) and three from Macera (MCZ 15929-15931).

Elgaria kingii nobilis Baird and Girard

Elgaria nobilis Baird and Girard, 1852, Proc. Acad. Nat. Sci. Philad., vol. 6: 129.

Elgaria marginata Hallowell, 1852, ibid.: 179.

Gerrhonotus nobilis, Baird, 1859, Rept. U.S. Mex. Bound. Surv.: 11.

Type:—In the U.S. National Museum; type locality, "Fort Webster, copper mines of the Gila (Santa Rita del Cobre), New Mexico."

Range:—Central and southern Arizona and southwestern New Mexico, intergrading with *E. k. kingii* in northwestern Chihuahua.

Diagnosis:—An *Elgaria* of the *kingii* group with 55-60 transverse rows of dorsals; the uppermost primary temporal usually (70%) separated from the uppermost secondary on one or both sides.

Remarks:—Although there is a slight overlap in dorsal scale count between this form and typical *kingii*, the difference seems sufficient to warrant recognition of two subspecies. If the line of separation is drawn between 55 and 56 transverse rows, then approximately 85% of the specimens can be correctly identified on this basis alone. In thirty-eight of the fifty-three United States specimens seen, the uppermost primary temporal is separated from the uppermost secondary on one or both sides; such a condition occurs in none of the eight referred to *k. kingii*.

Three specimens from Pacheco and one from Colonia Garcia, Chihuahua, show an intermediate dorsal scale count (see table). In two the uppermost primary and uppermost secondary temporals are separated on both sides, in another on one side, and in the fourth are in contact on both sides. These specimens would appear to represent a population intermediate between typical *kingii* and *k. nobilis*; they are therefore considered as intergrades. All United States specimens examined are definitely representative of *nobilis*.

A juvenile specimen, MCZ No. 27099, obtained by exchange from the U. S. National Museum, bears exactly the same data as USNM No. 8763, said to be from "Ralston, Arizona". The USNM specimen agrees in every respect with other examples of *E. k. nobilis*, but the MCZ specimen does not seem referable to the species *kingii*. It appears to represent some form of the *multicarinata* group, but no more exact determination is feasible. No known form of the *multicarinata* group occurs within the known range of *kingii*. I have

been unable to locate any Ralston, Arizona; it is possible that the locality datum on one or both specimens is erroneous. It is also possible that an undescribed representative of the *multicarinata* group does occur somewhere within the range of *k. nobilis,* and that the two specimens were actually collected at the same place. The recent discovery by Woodbury (1945) of a member of the *coerulea* group in southern Utah, far outside the previously known range of that group, lends credibility to the idea that a corresponding member of the *multicarinata* group may exist within the range of *k. nobilis.*

Dorsal Scale Counts of Elgaria kingii

Dorsal rows	*k. nobilis*	intergrades	*k. kingii*
51			2
52			2
53	1		2
54	1	2	
55	6		1
56	5	1	1
57	10		
58	16	1	
59	9		
60	2		
ave.	57.3	55.4	52.9

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A New Gerrhonotus from San Luis Potosi*

J. A. TIHEN, Harper, Kansas

Through the courtesy of Mr. George H. Lowery, Jr., of Louisiana State University I have recently been permitted to examine a series of *Gerrhonotus* from the vicinity of Xilitla, San Luis Potosi, Mexico. The specimens were obtained by a field party from Louisiana State University during the period from December, 1946 to August, 1947.

This series represents an apparently new race of *Gerrhonotus liocephalus,* which I have been granted permission to describe; I propose to name it in honor of Mr. Lowery, who has directed the work of the field parties and made the specimens available for study.

Gerrhonotus liocephalus loweryi, subsp. nov.

Holotype:—LSU No. 480; a young adult male. From the Xilitla region, San Luis Potosi, Mexico. Purchased, May 20, 1947, by Marcella Newman.

Paratypes:—LSU 472-479, 481-485, 485a, 486-487. All from the Xilitla region.

Range:—Known definitely only from the Xilitla region. A single specimen from near Ciudad del Maiz, San Luis Potosi, may be referable to this form.

Diagnosis:—A *Gerrhonotus* in which the number of loreal plus canthal elements on each side usually exceeds three; transverse dorsal scale rows 52-60; combined number of supralabials usually 24 or more; transverse bands obsolete; ventral surface nearly immaculate, occasionally very lightly marked; more than 150 caudal whorls; supranasals present; frontonasal as broad as or broader than long; second primary temporal usually in contact with the fifth medial supraocular.

Description of the holotype:—Postrostral present. Nasal separated from rostral by anterior internasals. Supranasals slightly expanded, in contact with postrostral. Two superposed postnasals; two loreals, two canthals, and two superposed preoculars. Frontonasal broader than long, not in contact with frontal or posterior canthals. One subocular, extending to antepenultimate supralabial; three postoculars. Six superciliaries, the most anterior not in contact with prefrontal. Frontal narrowly in contact with interparietal. Three primary (the normal second and third obviously fused) and four sec-

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*It is recognized that the concluding *i* of *San Luis Potosi* should be accented. Unavailability of the accent in our printer's font, however, accounts for its omission.—The Editor

ondary temporals, the uppermost primary in contact with uppermost secondary and lowest primary in contact with one (left) or two (right) lowest secondaries. Second primary temporal in contact with fifth medial supraocular. Supralabials 11 on left, 12 on right side; infralabials 11. Postmental paired, followed by four large and two smaller pairs of chinshields, of which the members of the anterior pair are in contact along the mid-ventral line. About seven sublabials, the most anterior extending to postmental and second infralabial.

Dorsals in sixteen longitudinal and fifty-four transverse rows; twelve longitudinal and sixty-seven transverse rows of ventrals. A minimum of eight scales in any row across nape. Caudal whorls 163.

Dorsum nearly uniform light brown; transverse bands obsolete. Venter with a few scattered melanophores, but definitely not mottled or flecked. Head light brown, somewhat lighter laterally than dorsally; a thin black line along pre- and suboculars, becoming diffuse on posterior labials and lower temporals.

Measurements in millimeters of the holotype:

Snout-vent	110	Axilla-groin	64
Tail	278	Fore limb	28
Head length	21.8	Hind limb	37
Head width	12.7	Fourth finger	7.8
Head depth	10.0	Fourth toe	11.1

Variation:—In one of the sixteen paratypes the posterior canthal is lacking; in two others the posterior loreal is small, and the large posterior canthal is in contact with the labials between the anterior and posterior loreals. Three loreals are present in six specimens. In one specimen there is an anomalous arrangement of the plates of the frontonasal region. One or two preoculars occur in about equal frequency; there are one to three, most frequently two, suboculars and two to four, usually three, postoculars. There are five superciliaries in two specimens, seven on one side of one; the anterior superciliary is in contact with the prefrontal on one or both sides of four specimens. Five primary temporals are present in two specimens, four in the remainder; the lowest primary is in contact with only the lowest secondary on one or both sides of four specimens (two of which are those with five primary temporals), with the two lowest secondaries in the remainder. The second primary temporal fails to contact the fifth medial suprocular in four specimens, of which two are those with five primary temporals. The supralabials vary from ten to fourteen, with the combined number varying be-

tween 22 and 27, 24 or more in thirteen of the sixteen paratypes. Infralabials vary between eight and twelve, ten being the most common number, but eleven is also frequent.

The number of transverse dorsal rows varies between 52 and 60, average 55.6; ventrals 61-70, average 65.2. Caudal whorls 157 in the only other specimen with a complete tail, 154 in one with the tail nearly complete.

The dorsal bands can be discerned in two or three specimens, but are very indistinct. The venter is normally immaculate or with a few scattered melanophores, lightly mottled in one, with scattered gray flecks in four others. These flecks are smaller, much less numerous, and lighter in color than those occurring in *l. ophiurus.*

Remarks:—In scutellation of the head (four loreo-canthals on a side, 24 or more combined supralabials) this form resembles *infernalis* and *ophiurus.* In color pattern (obsolete dorsal bands, unmottled venter), tail length and number of transverse dorsals and caudal whorls it resembles *liocephalus.* The contact of the second primary temporal with the fifth medial supraocular distinguishes this form from any of these other three (over 80% separation); this character may be shared with the Chiapan *austrinus.*

In the range of *infernalis* (Texas south to Alvarez, San Luis Potosi) there appears to be a cline from north to south affecting several characters. Tail length (and number of caudal whorls) is greater in the southern part of the range; the transverse bands become progressively less extensive, although not necessarily less distinct; the ventral surface becomes more heavily marked with black and gray. The Veracruz race, *ophiurus,* is essentially a continuation of this cline, and it is quite possible that other subspecies can be recognized as more material becomes available. Typical *liocephalus* is distinguished from both *infernalis* and *ophiurus* by the reduction in number of supralabials, the presence of only three loreo-canthal elements, the greater number of transverse dorsal scale rows, the greater length of the tail, the obsolescence of the dorsal bands, and the absence of prominent dark ventral markings. The present form, *loweryi,* is therefore intermediate between the *infernalis-ophiurus* complex and typical *liocephalus* in that it possesses certain features characteristic of each—although in length of tail and number of dorsals it would appear that this form differs from *infernalis* and *ohiurus* even somewhat more widely than does *l. liocephalus.* In view of this intermediacy it seems best for the present to consider

all the known forms of the genus as representing subspecies of the single species, *liocephalus*.

It should be noted, however, that the known range of *loweryi* is geographically intermediate between the range of *infernalis* and that of *ophiurus*, and well removed from the known range *of l. liocephalus*. Morphologically this form is in no respect intermediate between *infernalis* and *ophiurus*, differing from both of those forms in every respect in which it differs from either.

A single young specimen (LSU No. 488) from Ciudad del Maiz, San Luis Potosi, is tentatively referred to *loweryi*, chiefly on the basis of locality. This specimen has relatively prominent transverse bands (as do juveniles of *l. liocephalus*, although usually obsolete in specimens of this size—65 mm. snout-vent length), an immaculate venter, 53 transverse dorsal scale rows, two loreals and a single canthal on each side, twelve supralabials on a side, and the second primary temporal in contact with the fifth medial supraocular. Unfortunately, the tail has been broken and regenerated. It is unique, and possibly anomalous, in the absence of a true postrostral, possessing instead two anterior internasal elements on each side.

A Tabular Summary of the Subspecies of Gerrhonotus liocephalus

Form	dorsals	tail/body ratio	caudals	loreo-canthals, each side	supra-labials, both sides	dorsal bands	venter	2nd primary temporal contacts 5th medial supra-ocular
infernalis	45-54 (49.7)	1.75-2.1	116-137	4 or more	24 or more	distinct	mottled	no
ophiurus	49-52 (51.2)	2.3	app. 140	4 or more	24 or more	distinct	mottled & flecked	no
loweryi	52-60 (55.6)	2.5 -2.6	157-163	4 or more	24 or more	obsolete	nearly unmarked	yes
liocephalus	50-59 (54.0)	2.3 -2.4	143-149	3	23 or less	obsolete	usually unmarked	no
austrinus (one spec.)	53	?	?	3	21	obsolete	unmarked?	yes

The Distribution of the Hispid Cotton Rat in Kansas

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The hispid cotton rat, *Sigmodon hispidus*, Say and Ord, has expanded its range northward in Kansas during the past several years (Rinker, 1942; Hibbard, 1944). The aim of the present account is to summarize the information available, both published and unpublished, on the distribution, and expansion of the range of this sigmodont rodent in Kansas. Unless otherwise indicated, localities are in Kansas.

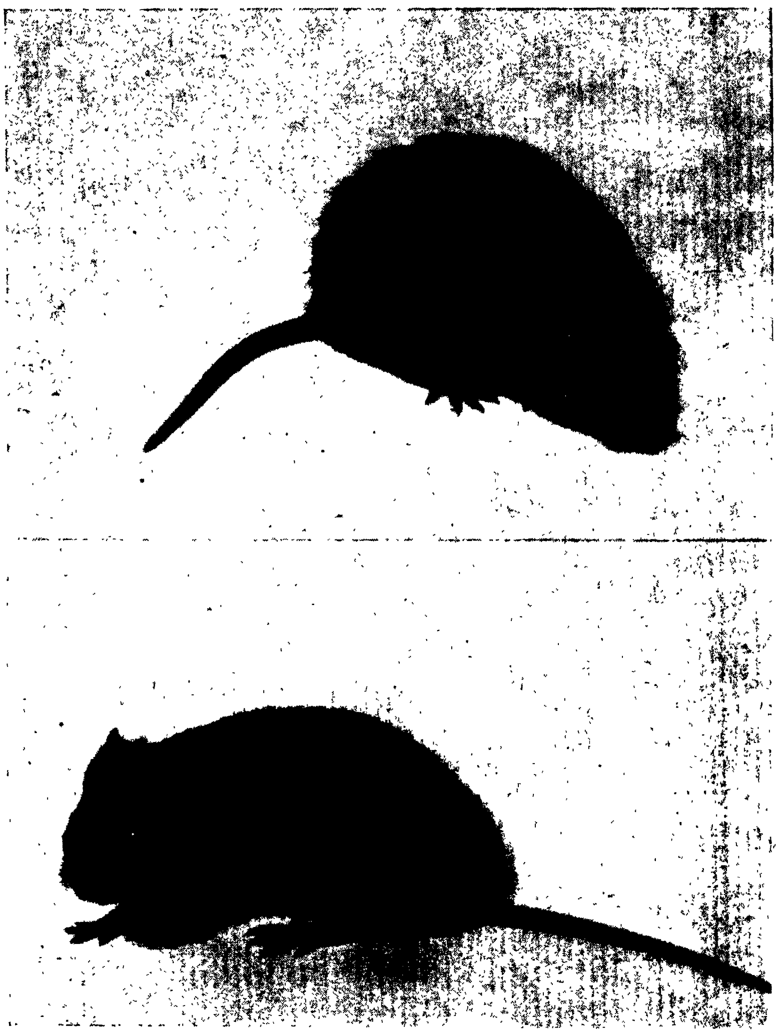
The cotton rat (figs. 1 and 2) weighs approximately four ounces and an adult is approximately ten inches in length, of which the tail comprises four inches. The color on the back and sides is grayish-brown to buffy-gray with an admixture of black, resulting in a grizzled appearance; the venter is paler (whitish) usually a light gray. The cotton rat can be separated from the Norway rat (*Rattus norvegicus*) and from the pack rats (*Neotoma* sp.) by the lesser total length and shorter tail. The pack rat is 14 to 15 inches in total length of which the tail makes up six to six and a half inches. The Norway rat has a total length of up to 16 inches; the tail makes up slightly less than half of this length.

The cotton rat, at times, becomes locally abundant, even numerous. In areas of such abundance, it is often a pest—even a menace—to the farmer. Grain crops are often damaged and yields of hay are noticeably reduced by its ravages.

The first record known to me of *Sigmodon* in the state is Bailey's (1902—A on map) mention of a specimen taken at Cairo, Pratt County, in the south-central part of the state, on July 29, 1892, by B. H. Dutcher. This specimen is number 35276/47541 in the United States National Museum. In the University of Kansas Museum of Natural History there is a specimen, no. 2088, taken by Alexander W. Wetmore at Independence, Montgomery County, on December 21, 1904 (B on map). In 1905, Lantz (1905) listed the cotton rat as a member of the Kansas fauna on the basis of the specimen, no. 35276/47541, previously reported by Bailey (1902).

In 1915 and 1916, cotton rats were taken in Labette, Cherokee and Neosho counties (C, D, and E on map) by various student assistants and employees at the University of Kansas Museum of Natural History. Remington Kellogg and Victor Householder took 52 specimens in the period December 27, 1915, to January 9, 1916, at four localities in Cherokee County (D on map). Kellogg wrote

of these (unpublished notes): "This species is extremely abundant. In some places corn that was left standing in the shock has been completely stripped . . . runways [of cotton rats] are everywhere . . . [The rats] were even eating Osage Orange." Householder's notes, also unpublished, concerning this same trip, record that: "The cot-



Figs. 1. (upper) and 2. A female cotton rat, in two different poses, caught alive on April 14, 1948, by James Bee, 3 miles southwest of Lawrence, Douglas County, Kansas. Photo by Thomas P. Lyle.

ton rat has entered the state from the south in great numbers during the last two years." These and other field notes referred to in the present account are in the files of the Museum of Natural History, University of Kansas.

Hibbard (1933) described the range of *Sigmodon* in Kansas as: ". . . east of the 99th meridian and the limits of its northern range

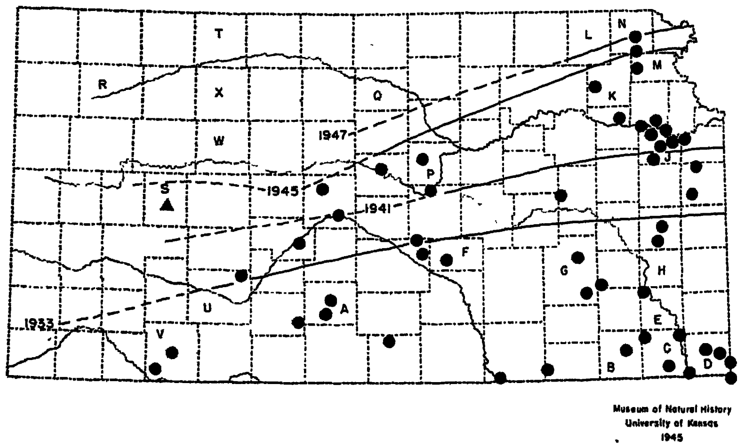


Fig. 3. Record stations within the state showing occurrence of the cotton rat (Sigmodon hispidus) by years.

is unknown but it is common in Harvey, Greenwood and Allen Counties [F, G and H on map]." Black (1937) ascribed much the same range to *Sigmodon*.

Although trapping (at times intensive) adequate to reveal the presence of *Sigmodon* if it had been present, has been done at various localities in Douglas County (J on map) from 1892 to the present, in which period hundreds of individuals of other kinds of mammals were obtained, including more than 100 *Peromyscus maniculatus bairdii* saved as specimens in the three years 1892, 1893 and 1894, it was not, however, until 1941 that *Sigmodon* was taken in Douglas County (Rinker, 1942). Hibbard (1944) wrote: "By the fall of 1942, the cotton rat was abundant in the fields and fence rows about Lawrence. That winter Rinker took . . . [it] north [northwest] of Lawrence at Lake View on the south banks of the Kansas river. The population was so numerous in Douglas County that . . . [the cotton rats] were common on the campus of the University, and one wandered into the basement of the Museum in the fall of

1942. At the present time (April 1944) they are abundant around Lawrence."

In an effort to obtain additional information on the northward movement of the cotton rat, Walter W. Dalquest trapped two specimeans of November 4, 1945, at a locality ten and a half miles west-southwest of Holton, Jackson County. Donald F. Hoffmeister, on November 16, 17, and 18, 1945, set traps at one locality in Pawnee County, Nebraska, and at one locality in Richardson County, Nebraska, at five localities in Nemaha County (L on map), and at two localities in the northern part of Atchison County (M on map). He did not take *Sigmodon* at any of these localities. However, in the latter part of the same month, Henry W. Setzer, E. W. Jameson, Jr., and A. Byron Leonard did take *Sigmodon* (12 specimens) in Atchison County at points one and a half and two miles south of Muscotah, only eight miles south of the southernmost locality tested by Hoffmeister.

Further efforts to obtain additional information on the northward movement of *Sigmodon* were made by the author, Robert B. Finley, Jr., and David C. Gordon, who trapped in Brown County (five localities) and Nemaha County (one locality), and in Richardson County, Nebraska (two localities), in November, 1947. Specimens of *Sigmodon* were taken only at the two southernmost localities in Brown County (see N on map).

There is little known concerning the distribution of *Sigmodon* in the central and western part of the state. Charles G. Sibley spent several months of the year 1942 in western Kansas, making a survey for the U.S. Public Health Service, with the principal aim of ascertaining if plague was present in the rodent population. In a personal communication, Sibley wrote: "Trapping was carried on in a systematic manner—200-400 traps being set at 5 mile intervals completely across the state along highway No. 283. We spent two weeks at each of the following towns: Meade, Dodge City, Ness City, Wakeeney, Hill City, and Norton. Field work was carried on in a 30 mile radius from each town so a fairly complete coverage of the area was made. Following are both presence and absence records."

For *Sigmodon* his records are, in effect, that none was found in June, July and August, in the vicinities of Wakeeney, Trego Co.; Hill City, Graham Co.; or Norton, Norton Co. (W, X and T on map). On May 9, 1942, the species was abundant at Meade, Meade Co. (V on map) and common at Dodge City, Ford Co. (U on map). On August 26, 1942, at a point two miles east of Dighton, Lane Coun-

ty (S on map), one individual was taken. It is now in the Museum of Vertebrate Zoology at the University of California, Berkeley, and was saved as a specimen because Sibley, at the time, recognized that it provided a marginal record of occurence.

Hoffmeister (field notes, K.U. Mus.) wrote on November 27, 1945: "Mr. Pinkenburg visited the Museum today and stated that this year, for the first time, cotton rats were present, in large numbers on his farm [1 mi. W and 2 mi. N Salina, Saline County, Kansas (P on map)]. Mr. Komarek, with Mr. Pinkenburg, likewise stated that cotton rats were present for the first time, and abundant, on his farm to the south of Mr. Pinkenburg's farm." On November 30, 1945, Mr. J. F. Komarek took one specimen of the cotton rat at a point one mile north of Bavaria, Saline County. This specimen is now number 17669 in the Museum of Natural History, University of Kansas.

The author with Henry W. Setzer and a party of students, trapped, in the summer of 1947, near Beloit, Mitchell County (four days), and near Colby, Thomas County, (two days). (See Q and R on map.) *Sigmodon* was not taken at these localities. Setzer trapped on four days in October, 1946, near Logan, Norton County (T on map), without taking *Sigmodon*. The work of these two field parties indicates that *Sigmodon* had not as yet reached the north-central and northwestern parts of the state.

The author solicits additional information on the movements of the cotton rat in Kansas. Information relative to records of occurrence, or observations of this animal's movements, may be sent to the author at the University of Kansas Museum of Natural History, Lawrence, Kansas.

Because of the lack of evidence in the form of specimens or sight records no attempt is made to show the status of *Sigmodon* in Kansas prior to 1933. However, in the period 1933 to 1941 the cotton rat expanded its range northward in Kansas apparently from Greenwood and Allen counties (G and H on map) to Douglas County (J on map), an airline distance of between 35 and 40 miles. Between February, 1941 (the date of capture of the first specimen from Douglas County), and November, 1945, *Sigmodon* seems to have moved at least 45 miles farther northward into Atchison and Jackson counties (K and M on map). Between November, 1945, and November, 1947, *Sigmodon* is thought to have expanded its range at least 15 miles farther northward into Brown County (N on map). Thus, in a period of 14 years, *Sigmodon* appears to have expanded

its range northward approximately 100 miles. If the spread northward was at a constant rate the distance per year works out to be seven and a fraction miles.

The probable northern limit of occurrence of *Sigmodon* in Kansas for the years 1933, 1941, 1945, and 1947, together with the localities from which specimens have been examined, are indicated on the map (fig. 3). In the following list of specimens examined (all of which are in the collection of the University of Kansas Museum of Natural History) the year in parentheses after the locality is the first year in which specimens were recorded from a given locality.

Specimens examined.—Total number, 409, distributed as follows: *Brown County*: 5 mi. S Hiawatha, 1 (1947); 1 mi. N Horton, 2 (1947). *Jackson County*: 10½ mi. WSW Holton, 2 (1945). *Atchison County*: 1½ mi. S Muscotah, 6 (1945); 2 mi. S Muscotah, 6 (1945). *Jefferson County*: Buck Creek, 900 ft., 1 mi. N and 3¼ mi. E Williamstown, 1 (1945); 1½ mi. E, 7½ mi. N Lawrence, 1 (1945); 1½ mi. E, 4½ mi. N Lawrence, 1 (1945). *Saline County*: 1 mi. N Bavaria, 1 (1945). *Shawnee County*: 3 mi. W, 4½ mi. N State Capitol Bldg., Topeka, 2 (1947). *Douglas County*: 1 mi. N Midland, 1 (1945); ½ mi. NW Lecompton, 1 (1945); Lakeview, 1 (1942); 3 mi. NE Lawrence, 3 (1945); ¼ mi. W Lawrence, 2 (1941); 1½ mi. WSW Lawrence, 1 (1944); 7½ mi. SW Lawrence, 4 (1941); Rock Creek, 850 ft., 10 mi. SW Lawrence, 2 (1944); N end Lone Star State Lake, 9 mi. S, 7 mi. W Lawrence, 3 (1946). *Johnson County*: 1 mi. NW Community Bldg., Sunflower, 1 (1947); Sunflower Village, 2 mi. SW DeSoto, 1 (1947). *Barton County*: 3 mi. N, 2 mi. W Hoisington, 16 (1945); 1½ mi. W, ½ mi. S Ellinwood, 1 (1945). *Ellsworth County*: Ellsworth, 1 (1946). *McPherson County*: Smoky Hill River, 1 mi. S, ½ mi. W Lindsborg, 16 (1945); 1 mi. S Lindsborg, 2 (1945). *Lyon County*: 6 mi. W, 5 mi. N Emporia, 3 (1945). *Anderson County*: ½ mi. SE Welda, 12 (1946); 3.7 mi. S Garnett, 1 (1946); 7 mi. S Garnett, 1 (1946). *Miami County*: 9 mi. N Paola, 1 (1946); 11 mi. SSE Paola, 46 (1946). *Pawnee County*: 2 mi. S, 1 mi. E Larned, 3 (1945); 3 mi. S, 1½ mi. W Larned, 2 (1945). *Reno County*: 1 mi. N, 2 mi. W Medora, 2 (1945); 2 mi. W Medora, 1 (1945); 2 mi. W, ½ mi. S Medora, 10 (1945); 8 mi. N, 1 mi. E Haven, 2 (1945). *Harvey County*: 1 mi. S Halstead, 9 (1922); 1 mi. S, ½ mi. E Halstead, 8 (1922); 2 mi. S, ½ mi. E Halstead, 1 (1922). *Greenwood County*: ½ mi. S Hamilton, 1 (1946); 1 mi. S Hamilton, 1 (1940); 8 mi. SW Toronto, 9 (year?); 8½ mi. SW Toronto, 16, (1931, 1932). *Allen County*:

2 mi. W Petrolia; 1 (year?). *Ford County*: ½ mi. NW Bellefont, 6 (1945). *Kiowa County*: Rezeau Ranch, 5 mi. N Belvidere, 3 (1939). *Pratt County*: Fish Hatchery, 1 (1916); unspecified, 2 (1921). *Neosho County*: 3 mi. NW Chanute, 1 (1916). *Meade County*: Meade County State Park, 4 (1937); 14 mi. SW Meade, 4 (year?); 17 mi. SW Meade, 63 (1940); unspecified, 7 (1941). *Harper County*: 5 mi. NW Harper, 4 (1938); 3 mi. S Harper, 10 (1938); 4½ mi. NE Danville, 6 (1939). *Cowley County*: 3 mi. SE Arkansas City, 18 (1938). *Chautauqua County*: 1½ mi. SW Cedarvale, 3 (1938). *Montgomery County*: Independence, 1 (1904). *Labette County*: 10 mi. E, 1½ mi. N Parsons, 4 (1947); 11 mi. W Parsons, 2 (1947); 10 mi. E Parsons, 3 (1947); 8 mi. SW Oswego, 2 (1915); 10 mi. SW Oswego, 1 (1915). *Cherokee County*: Columbus, 1 (1916); 1 mi. W Columbus, 1 (1916); 4 mi. E Columbus, 22 (1916); 3 mi. S Galena, 1 (1945); 18 mi. SW Columbus [by road], 22 (1915); 3 mi. E Baxter Springs, 900 ft., 3 (1945); ½ mi. N, ½ mi. W Tri-State Monument, 1 (1945).

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A Burrow of the Pocket Gopher (*Geomys bursarius*) in Eastern Kansas

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On the morning of November 29, 1947, one-fourth mile south and two miles west of Lawrence, Douglas Co., Kansas, I trapped a female pocket gopher (*Geomys bursarius majusculus* Swenk) and began excavating its burrow to ascertain the nature of the winter quarters of this animal. The external measurements of the gopher were: total length, 260 mm; length of tail, 80 mm; length of hind-foot, 32 mm.

Parts of five consecutive days were devoted to excavating the burrow. I am convinced that the female was the only pocket gopher living in the burrow for, whenever I left it, I set traps in such a manner as made it impossible for a pocket gopher to escape by means of the opened end of the burrow and always, upon returning, I checked the area for open holes to learn if a gopher had left or entered the burrow anywhere else. The traps never were sprung and I never discovered any accessory hole.

The burrow was in black loam in a flat area which had no appreciable amount of drainage in any one direction. The conspicuous vegetation of the field consisted of composites and grasses as follows: *Helianthus tuberosa, Ambrosia trifida, Solanum carolinense, Chenopodium basianum, Physalis pumila, Ambrosia elatior, Helianthus annus, Abutilon theophrasti, Tridens flavus, Setaria lutescens* and *Bromus inermis.*

The mounds above ground were typically fan-shaped. None was directly over the main burrow, but each was to one side of it, at the end of an inclined, lateral tunnel. The arrangement of the mounds of earth indicated that they all were associated with a single burrow, as later was proven to be the case. There was no sign of another burrow of a pocket gopher within a thousand yards. All of the burrow was excavated. It consisted of only one main tunnel. This was open but there were many short, lateral branches, which had been used in the past but which now were plugged with soil (see figure 1). These laterals from the main burrow may have been dug in an underground search for food; at any rate, the greater number of the laterals did not reach the surface of the ground. The floor

of the main burrow for the most part, was between six and nine inches below the surface of the ground. The greatest depth was thirty-eight inches; this was in the vicinity of the nest. The oval burrow, throughout, was remarkably consistent in the dimensions of its cross-section, being three inches wide and four and a half inches high. The total length of the main burrow was two hundred and six feet. More than seventy cubic feet of earth had been removed to make this one main burrow. Since all of the mounds were fresh (no plants grew through any mound and no old mounds were found) and since only one gopher is thought to have been involved, it alone would appear to have moved all of this soil in less than one year.

The bottom of the nest was twenty-four inches below the surface of the ground. In inches, the nest measured 7 x 3½ x 6½ and was constructed entirely of the cut stems, approximately one and a half inches in length, of the three kinds of wild grass which were abundant in that area, namely *Tridens flavus, Setaria lutescens,* and *Bromus inermis.* The nest was so constructed that there was more insulation on the top and sides than on the bottom. The nest was free of fecal material and appeared to lack parasites and commensals, but did contain five small pieces of bone which bore toothmarks of pocket gopher size. Possibly the bone had been used either to supply calcium for the gopher or had been used by her as a whetstone for grinding away the ends of the long, evergrowing incisor teeth. The bones may have served both purposes.

All fecal material was found in short, plugged-up tunnels approximately nine inches in length that originally branched from the main burrow. After the tunnel was almost full of feces, the gopher plugged the remaining part with soil. As a result, the main tunnel was free of fecal material.

There were food stores at two places along the tunnel (see figure 1). One store was in a mere enlargement of the end of a side tunnel, and the other store was in a pocket in one side of the main tunnel. This pocket opened into the main tunnel, but the larger food store was farther from the nest, at the end of the side tunnel. It had two earth plugs separating it from the main burrow. The stores consisted entirely of the tubers of the sunflower, *Helianthus tuberosa.* The smaller store, of 39 pieces of tubers, weighed 238 grams and the larger, of 90 tubers or parts thereof, weighed 444.5 grams. The tubers had been cleanly cut from the plant and all fibrous roots had been shaved off. I wondered if the removal of the

fibrous roots prevented the growth of the tubers while they were stored. The tubers were packed so that they occupied the minimum of space; they had not been haphazardly introduced into the cache.

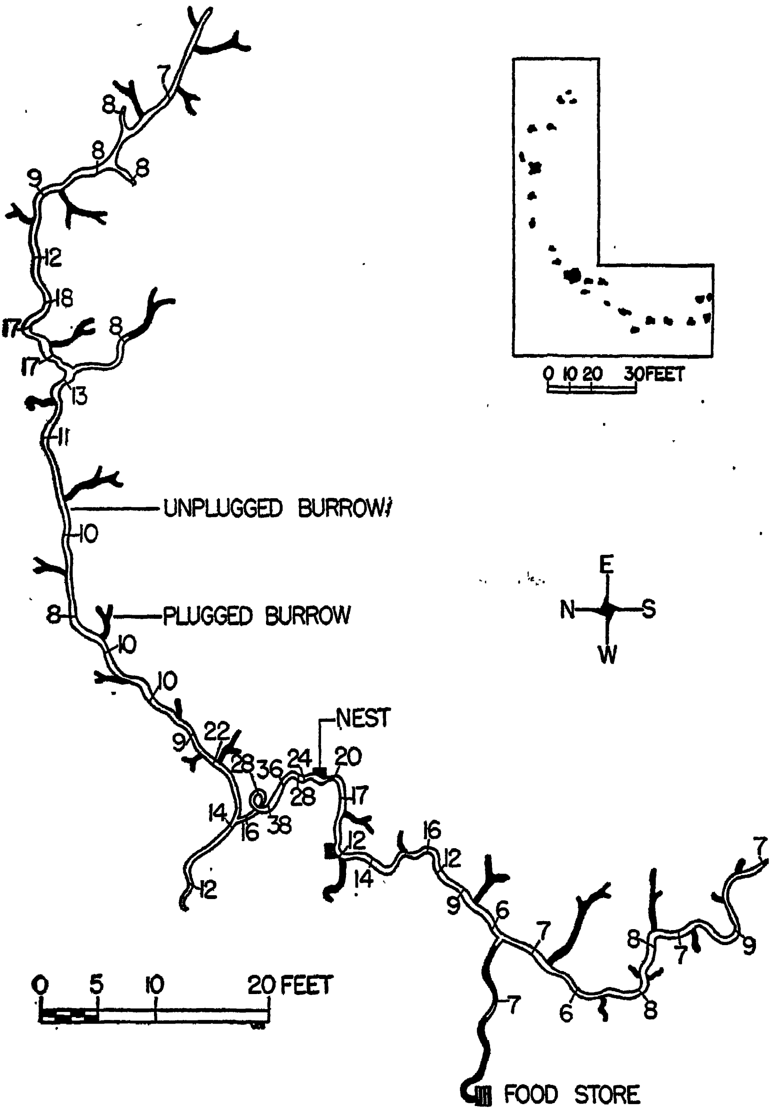

Figure 1. Drawing, looking down on the burrow of the pocket gopher. Numerals are measurements in inches of depth, below the surface of the ground, of the burrow. Drawing at upper right shows the mounds of earth on the surface of the ground.

An Additional Specimen of the Rodent Dikkomys From the Miocene of Nebraska

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In 1936 Wood described as new the genus and species *Dikkomys matthewi* based upon a p4, ml, m2, and Ml. Therefore the discovery of additional material, referable to the genus, and, for the time being, to the species *D. matthewi,* adds a little more information concerning this unusual geomyid.

Dikkomys matthewi Wood

Dikkomys matthewi Wood, Amer. Mus. Nat. Hist. Novitates no. 866, p. 26, fig. 32. July 2, 1936.

Referred material:—C.N.H.M. no. P26284, an incomplete right mandible with p4-m3; Upper Rosebud, Shannon County, South Dakota. The writer is indebted to Mr. Bryan Patterson of the Chicago Natural History Museum for the loan of this specimen and permission to describe it.

The ramus of the mandible is similar to, although smaller than, that of *Pleurolicus sulcifrons* Cope. Compared to the ramus of *Gre-*

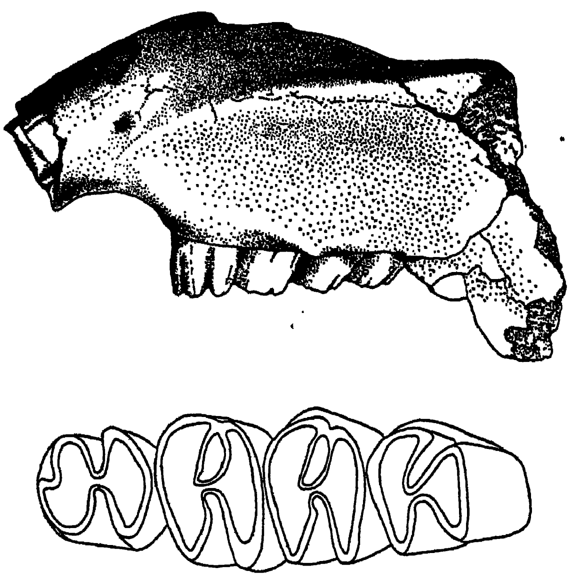

Fig. 1. Dikkomys matthewi Wood. C.H.N.M. no. P26284. Crown view of right p4-m3 (x 11.), and lateral view of the right lower jaw (x 5.).

gorymys curtus (Matthew) it is shorter relative to its height. The masseteric ridge extends anteriorly beyond the p4 as a faint crest, ending midway between the mental foramen and the lowest point of the diastema. Posteriorly, the crest of the ridge extends to the tip of the large angular process. There is no masseteric fossa. As in *Pleurolicus,* a shallow pit is present between m3 and the base of the coronoid process.

The cheek-teeth are rooted, and the crowns are of medium height. The enamel investment is complete, and forms lophids similar to those of the type specimen. An anterior cingulum that is somewhat narrower than that in the type specimen is present on p4. The inner reentrant angles between the two lophids are much deeper vertically than are the external angles. In the m1 and m2 this condition leads to the buccal union of the lophids, and the formation of a lake in each tooth at a certain stage of wear. The apices of the reentrant angles between the two lophids of the first two molars are turned slightly anteriorly. Each internal and external angle has the enamel at the apex thinner than in the arms.

MEASUREMENTS
(In millimeters)

	C.N.H.M. No. P26284	A.M.N.H. No. 22720* (Holotype)	A.M.N.H. No. 22721*
Crown length of p4-m3	6.30**	-- --	-- --
Depth from crown of p4 to posterior end of symphysis	7.80	-- --	-- --
Length from posterior end of *diastema to angular process*	10.56	-- --	-- --
p4, antero-posterior length	1.74	1.93	-- --
p4, metalophid width	1.34	1.30	-- --
p4, hypolophid width	1.50	1.43	-- --
m1, antero-posterior length	1.59	-- --	1.55
m1, metalophid width	1.90	-- --	1.83
m1, hypolophid width	1.85	-- --	1.74
m2, antero-posterior length	1.40	-- --	-- --
m2, metalophid width	2.50	-- --	-- --
m2, hypolophid width	1.90		
m3, antero-posterior length	1.45		
m3, metalophid width	1.70		
m3, hypolophid width	1.22		

* From Wood, A. E. Geomyid Rodents From the Middle Tertiary. Amer. Mus. Nat. Hist. Novitates, no. 866, pp. 1-31, 33 figs. 1936.

**Measurements of the teeth are of the occlusal surfaces.

Kansas Phytopathological Notes: 1947[1]

E. D. HANSING and C. O. JOHNSTON[2]
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Publication of miscellaneous notes and observations on the occurance, distribution, severity, and importance of plant diseases in Kansas will be recorded in Kansas Phytopathological Notes beginning with this paper. This report covers the calendar year 1947. Herein are presented field observations made by plant pathologists and others during travel in all parts of the state and laboratory observations on disease specimens received for identification. A special effort is made to record pertinent facts regarding the plant diseases of major economic importance and of those assuming unusual importance.

1947 Weather as Related to Plant Diseases

Weather conditions in 1947 were unusual in that part of the year was cool and wet and the remainder hot and dry although the average annual precipitation and temperature for the state were approximately normal (table 1). January was moderately warm

Table 1.—1947 Meteorological data for Kansas showing means and deviations from the mean precipitation and temperature.[1]

	Precipitation in Inches					Temp. in degree F.	
	Deviation from mean			State		State	
	East Third	Central Third	West Third	Mean	Deviation	Mean	Deviation
Jan.	—0.49	—0.04	+0.16	0.58	—0.12	32.9	+2.8
Feb.	—0.93	—0.63	—0.41	0.32	—0.66	31.4	—1.9
Mar.	+1.41	+1.02	+0.54	2.47	+0.99	39.0	—4.5
Apr.	+3.71	+2.05	+1.12	4.67	+1.96	52.5	—2.3
May	—0.01	+0.58	+1.48	4.50	+0.69	60.9	—2.9
June	+2.09	+1.10	+0.31	5.20	+1.17	71.8	—2.0
July	—1.48	—1.29	—0.79	1.91	—1.19	77.6	—1.6
Aug.	—1.60	—1.65	—0.68	1.84	—1.31	83.2	+5.2
Sept.	—0.76	—2.28	—1.27	1.40	—1.43	74.0	+4.2
Oct.	—0.54	—0.91	—0.61	1.29	—0.69	65.8	+8.3
Nov.	—0.51	—0.15	+0.35	1.17	—0.10	39.5	—3.7
Dec.	+1.42	+1.50	+0.62	2.08	+1.17	34.3	+1.2
	Precipitation, mean temperature, and deviations						
Annual	37.60	25.74	18.94	27.43	——	55.2	—..
Dev.	+2.31	—0.70	—0.18	+0.48	——	+0.2	—..

[1]Data compiled from monthly reports by S. D. Flora, in Climatological Data, Kansas Section, U. S. Department of Commerce, Weather Bureau, LXI, Nos. 1-13, 1947.

[1]Contribution No. 495, serial No. 400, Dept. of Botany, Kansas Agricultural Experiment Station.

[2]Plant Pathologist, Kansas Agr. Exp. Sta., and Pathologist, Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U.S. Department of Agriculture, respectively.

Transactions Kansas Academy of Science, Vol. 51, No. 3, 1948.

with normal precipitation. The months of February to July, inclusive, were moderately cool and at the end of July there was an accumulated deficit in temperature for the five-month period of —15.2° F. February was moderately dry while the next four months were moderately wet. The months of August, September, and October were very warm. High temperatures, together with a deficiency in precipitation in July and during each of these months were unfavorable for such crops as corn, sorghum, and soybeans. November was cold with normal precipitation while December was moderately warm and moderately moist.

The moderately warm winter and the cool moist spring were very favorable for wheat production, and the wheat crop of 286,-702,000 bushels (farm value $673,750,000) was the largest ever harvested in the state. Although the spring was moderately moist and farmers had great difficulty in getting their oats and barley planted, the weather during the growing season was favorable for these crops and good yields were obtained except where they were partially destroyed by Victoria blight and smut, respectively. The moist spring delayed the planting of such crops as corn, sorghum, and soybeans. Although the precipitation was above normal during the spring, the available soil moisture was depleted during July; consequently, these crops did not yield so well as in 1946.

The deficiency in precipitation from July to October was unfavorable for emergence of wheat planted in the fall of 1947. A high percentage of the wheat in central and western Kansas did not have sufficient moisture for emergence until November and December, respectively.

Observations on Cereal Rusts and Smuts

Infections of rusts on cereal crops in Kansas in 1947 were the lightest observed since the early drought years of the preceding decade. In many parts of the state infections were the lightest ever observed, and the near absence of rust in large sections of the state undoubtedly had some relation to the unprecedented wheat yield of 286 million bushels.

There are many features of the rust situation in relation to the 1947 wheat crop that were unusual and should be recorded. Good rains fell in western Kansas during the summer and fall of 1946. As a consequence there were thousands of acres of volunteer and early sown wheat. Much of the early sown wheat was planted in August for pasture. Both volunteer and early sown wheat made great vegetative growth and were grazed very heavily. Rains continued

throughout the fall, and leaf rust (*Puccinia rubigo-vera tritici*) infection became extremely heavy. It was still heavy on November 1 and conditions seemed favorable for abundant overwintering of the leaf rust of wheat in Kansas. Despite favorable fall factors, however, there was very little overwintering of leaf rust and it was difficult to find in most fields the following spring until late in May when spores began moving into the state in abundance from regions farther south.

One of the most interesting features of the infections of rust on wheat in 1947 was that they were heavier in the western half of the state than in the eastern half. Both leaf rust (*P. rubigo-vera tritici*) and stem rust (*P. graminis tritici*) of wheat moved into Kansas from western Oklahoma and the adjacent parts of Texas. Fortunately, however, the infections developed late in the season and the advent of hot, dry weather after the middle of June caused the wheat to ripen rapidly with only occasional local losses. While leaf rust of wheat was fairly heavy in western Kansas, it was unusually light in eastern counties and stem rust was practically absent in that area.

Crown rust (*P. coronata avenae*) and stem rust (*P. graminis avenae*) of oats also were unusually light in Kansas in 1947. This was partially due to the increase in the acreage of resistant varieties such as Osage, Neosho, Boone, Tama, and Vicland. During the last half of June considerable stem rust developed on susceptible oat varieties. There probably was more loss from stem rust of oats than from any other cereal rust.

While the severity of all rusts was low in Kansas in 1947, it seems desirable to record the following estimated losses as a matter of record:

Leaf rust of wheat (*Puccinia rubigo-vera tritici*)	trace
Stem rust of wheat (*P. graminis tritici*)	trace +
Crown rust of oats (*P. coronata avenae*)	present, no loss
Stem rust of oats (*P. graminis avenae*)	1 per cent
Leaf rust of barley (*P. hordei*)	present, no loss
Stem rust of barley (*P. graminis*)	trace
Leaf rust of rye (*P. dispersa*)	present, no loss
Stem rust of rye (*P. graminis secalis*)	present, no loss
Rust of corn (*P. sorghi*)	present, no loss

Loose smut (*Ustilago tritici*) of wheat caused an estimated loss of 0.2 per cent in 1947. The maximum infection observed was 5 per cent in a field of Early Blackhull wheat in Cherokee County. The deficiency in precipitation during the blossom period in the latter half of May, 1946, was unfavorable for loose smut infection. This was the least loss in susceptible varieties from this disease since

1937. Fields of Pawnee and Kawvale were free from loose smut except in rare cases where a trace of smut was found, which may have been in impurities of other varieties in these fields.

Bunt (*Tilletia foetida*) of wheat was not so severe in Kansas in 1947 as it was in 1946. The average estimated loss for the state for this disease in 1947 was 0.1 per cent. A few fields were reported in south central Kansas with a loss of 50 per cent. Fields of Pawnee and Comanche that were examined were free from bunt with the exception of a field of Pawnee in Dickinson County which had a trace of this disease.

Smut (*Ustilago avenae* and *U. kolleri*) of oats caused an estimated loss of 1 per cent in 1947, which was less than has occurred since 1944. This reduction in loss from smut in 1947 was due in part to the growing of resistant varieties and in part to unfavorable environmental conditions during planting of the crop in March. The maximum infection observed was 21 per cent in a field of Kanota in Cowley County. The average loss in Kansas in fields of Kanota and Fulton was 6 and 0.5 per cent, respectively. Fields of Osage, Neosho, Boone, Tama, Cedar, and Vicland were free from smut except in a few cases where a trace was observed.

Brown loose smut (*Ustilago nuda*), black loose smut (*U. nigra*), and covered smut (*U. hordei*) of barley caused estimated losses of 6.0, 4.0, and 2.0 per cent, respectively. Maximum infections of 43 per cent were found in a field of Beecher spring barley in Rooks County and 37 per cent in a field of Reno winter barley in Stafford County. Although weather conditions were unfavorable for loose smut infection of wheat in 1946, they were favorable for infection with brown loose smut of barley.

Notes on Miscellaneous Plant Diseases

Another unusual cereal disease development in 1947 was the heavy infection and wide distribution of mildew (*Erysiphe graminis tritici*) on winter wheat. In the average year mildew can be found in low spots in the early spring but it seldom becomes generally abundant in large areas as it did in 1947. During May, infections were widespread and heavy on wheat, both on upland and in the river valleys in a broad strip across the center of the state from south to north. At Manhattan, infections were so heavy in nursery sowings that they interfered with the development of other leaf diseases. In varietal plots on upland at the agronomy farm, mildew infections were heavy up to mid-height on the plants.

Scab (*Gibberella zeae*) of wheat was more prevalent and se-

vere in Kansas than it has been for any year during the last two decades. Traces of this disease were observed in all parts of the state. The disease was especially severe in northeastern Kansas with maximum losses of at least 10 per cent occurring in a few fields. The average loss for the state was 0.1 per cent.

The increase in severity of Victoria blight (*Helminthosporium victoriae*) of oats from 1946 to 1947 in Kansas was phenomenal. The disease was generally distributed in every section of the state. The losses, however, were greater in eastern than in central Kansas. The estimated loss in susceptible varieties in northeastern Kansas was 30 per cent, in southeastern Kansas 20 per cent, in central Kansas 5 per cent, and in western Kansas 0.1 per cent. The loss from this disease in Kansas was 6,000,000 bushels of grain at a farm value of $6,000,000. Losses were greater in Iowa, Nebraska, and other states in 1947 than in 1946.

Cherokee, Nemaha, and Clinton were recommended as new varieties for distribution in Kansas in 1948. These varieties are highly resistant to Victoria blight and resistant to rust and smut. In some county cooperative variety tests in eastern Kansas, these new varieties lodged less than 1 per cent while such varieties as Osage, Neosho, Boone, and Tama lodged from 25 to 100 per cent.

Anthracnose (*Colletotrichum graminicolum*) of oats was more prevalent and severe in Kansas than it has been at any time since observations were first reported in 1917. The disease was most severe in southeast Kansas; however, it caused only slight lodging, while in some of the other north central states it caused severe lodging in many varieties. The estimated loss from this disease in Kansas was 0.1 per cent.

The hot, dry weather during August and September was very favorable for such diseases as charcoal rot (*Sclerotium bataticola*) of sorghum and corn, and Nigrospora cob rot (*Nigrospora oryzae*) of corn. Losses from these diseases were greater in 1947 than they had been for several years.

Ergot (*Claviceps purpurea*) was very severe on *Agropyron* spp. x wheat hybrids in the nursery near Manhattan. Several of the hybrid lines produced more sclerotia than seed.

Phytophthora root rot (*Phytophthora spp.*), a soft rot of the root and crown of sweetclover was more prevalent and severe during the spring than it has been for many years. It was especially destructive on second year sweetclover. The cool, wet spring was also very favorable for leaf spots of alfalfa and other crops during

this season. The warm, dry weather from August to October was unfavorable for these diseases, and alfalfa, Sudan grass, sorghum, and soybeans were relatively free from fungous and bacterial leaf spots. Physiological leaf spots of Sudan grass and sorghum, however, were more common than usual.

The cool, wet spring was very favorable for peach leaf curl (*Taphrina deformans*). This disease was more prevalent and severe in central and eastern Kansas than it has been since records were first reported.

Phloem necrosis of the American elm continued to spread slowly in 1947. Most of the trees which were infected and either died or were cut down occurred in east central Kansas. One tree was reported in Manhattan during the year and was cut down so as to prevent spread of the disease to other trees.

First Year Invasion of Plants on An Exposed Lake Bed

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Leavenworth County State Park located about four miles northwest of Tonganoxie in Leavenworth County, Kansas, has an artificial lake of about 175 acres. For several years the lake was a popular fishing area but during the past few seasons fishing became steadily worse. The state game and fish commission decided to drain the lake in order to make a study of the area and accordingly they began to drain the lake in December of 1946. In the fall of 1947 the lake was again allowed to fill. The purpose of this paper is to report on a study made of the plants which appeared on the lake bed during the season following the draining of the lake.

The lake known locally as Tonganoxie Lake was constructed in 1931 when a dam was placed across a valley which forked above the dam to form two arms in the lake. The valley was deep and had rather abrupt banks. The lake had a maximum depth of about 40 feet. In the upper end of the arms the water was from a few inches to a few feet deep and shallow water was also found in a few small bays or coves in the shore line. In general, though, the water was quite deep since the banks of the lake were rather abrupt.

Several small creeks supplied water for the lake. Two of these tributaries were much more important than the rest. One ran into the west arm of the lake, the other into the east arm of the lake. Their drainage areas consisted of woodlands, fields, and some prairie. The other tributaries drained the wooded hilly regions immediately surrounding the lake.

By April of 1947 most of the water had been removed from the lake. The lake bed exposed was rough. A study of the soil showed that silting had not been too severe. In general it was limited to a few inches, though in some areas it measured several feet.

During May and June seedlings began to appear on the lake bed in great numbers. In July conditions had progressed to the point where collections could be made and a comparative study started.

From the beginning of the study it was apparent that *Polygonum lapathifolium* L. was the dominant plant over the entire lake bed. Individuals of this species composed about 90% of the flora of the lake bed and formed a dense growth over nearly the entire exposed surface.

Several species were conspicuous in that they formed localized colonies here and there over the lake bed. Such species were: *Lindernia anagallidea* (Michx.) Pennell; *Lippia lanceolata recognita* Fernald and Griscom; *Mollugo verticillata* L.; *Polygonum hydropiperoides* Michx.; *Eragrostis hypnoides* (Lam.) B.S.P.; *Leersia oryzoides* (L.) Swartz.; *Ipomoea hederacea* Jacq.; *Bidens glaucescens* Greene, and *Cuscuta polygonorum* Engelm.

A number of other species were found commonly but were quite widely scattered over the area. These species were: *Ambrosia elatior* L.; *Rorippa sessilifolia* (Nutt.) Hitchc.; *Erigeron canadensis* L.; *Helianthus annuus* L.; *Ipomoea lacunosa* L.; *Cyperus ferruginescens* Boeckl.; *Euphorbia maculata* (L.) Small; *Trifolium procumbens* L.; *Juncus interior* Wieg.; *Echinochloa crusgalli* (L.) Beauv.; *Polygonum coccineum pratincolum* (Greene) Stanford; *Polygonum punctatum* Ell.; *Populus deltoides* Marsh; *Salix amygdaloides* Anders.; *Salix interior* Rowlee; *Salix nigra* Marsh and *Ulmus americana* L. The last five of these were seedlings of those species.

A number of species, in addition to the ones listed above, were found here and there over the area. They were of rare occurrence and are included in the list of plants at the end of this paper.

Certain plants were found at rather definite water levels. The most outstanding example of this was *Bidens involucrata* (Nutt.) Britton. This plant was found at a level of about six feet below the water level of the lake before draining was started. *Cuscuta polygonorum* Engelm. was found abundantly at a level of from two to six feet below the water level before draining was commenced. It was parasitic on *Polygonum lapathifolium* L. and *Bidens involucrata* (Nutt.) Britton. The tree seedlings mentioned above were found mostly at a level of about ten to fifteen feet below the normal water level of the lake. This was about the water level at the time the seeds of these trees were shed.

The greatest number of species was found in the areas just below the entrance of tributaries into the lake and in the lower more moist areas in other regions of the lake bed. It was in these areas that most of the species listed as occurring in local areas, common though scattered and those as of rare occurrance were found. Also in these areas were found several Bryophytes of which *Riccia frostii* Austin; *Bryum caespiticium* (L.) Hedw.; *Cratoneuron filicinum* (Hedw.) Roth.; *Leptodictyum trichopodium* (Schultz) Warnst. and *Mnium cuspidatum* Hedw. were the most common. One Pteridophyte was found. It consisted of numerous game-

tophytes of a species of *Equisetum*. No sporophytes were found.

During the course of this study, seed plants were found representing 36 families, 62 genera and 93 species. Of the total number of species, 41 were not previously listed for Leavenworth County. None of these species are considered rare, however, as they all were observed growing at one time or another in the drainage area of the lake and most are of common occurrance in the county and in eastern Kansas.

The following list includes all the species of seed plants found during the course of this study. The families are listed alphabetically as are the genera and species in each family. Those species designated by an asterisk are those reported from Leavenworth County for the first time. A specimen of each species found has been placed in the herbarium at the University of Kansas.

Aizoaceae
Mollugo verticillata L.

Alismaceae
Sagittaria latifolia Willd.

Amaranthaceae
Amaranthus hybridus L.
Amaranthus retroflexus L.

Ambrosiaceae
Ambrosia elatior L.
Ambrosia trifida L.
*Xanthium italicum Mor.

Ammiaceae
*Sium suave Walt.

Apocynaceae
*Apocynum cannabinum glaberrium DC.

Brassicaceae
*Lepidium virginicum L.
Rorippa hispida glabrata Lunell.
*Rorippa sessilifolia (Nutt.) Hitchc.

Cassiaceae
Chamaecrista fasciculata (Michx.) Greene

Chenopodiaceae
Chenopodium album L.
*Chenopodium boscianum Moq.
Chenopodium gigantospermum Aellen.

Cichoriaceae
*Lactuca serriola L.
Taraxacum vulgare Lam.

Commelinaceae
*Commelina virginica L.

Compositae
Bidens glaucescens Greene
Bidens involucrata (Nutt.) Britton
Eclipta alba (L.) Hassk.
Erigeron canadensis L.
Erigeron ramosus (Walt.) B.S.P.
*Helianthus annuus L.

Convolvulaceae
*Ipomoea hederacea Jacq.
*Ipomoea lacunosa L.
*Ipomoea purpurea (L.) Roth.

Crassulaceae
Penthorum sedoides L.

Cuscutaceae
*Cuscuta polygonorum Engelm.

Cyperaceae
*Cyperus diandrus Torr.
*Cyperus ferruginescens Boeckl.
*Cyperus inflexus Muhl.
Cyperus strigosus L.
Eleocharis obtusa (Willd.) Schultes

Euphorbiaceae
Acalypha virginica L.
*Croton monanthogynus Michx.
*Euphorbia dentata Michx.
*Euphorbia heterophylla L.
Euphorbia hyssopifolia L.
Euphorbia maculata (L.) Small
*Euphorbia marginata Pursch.
*Euphorbia serpens H.B.K.

Fabaceae
*Trifolium procumbens L.
*Vicia sparsifolia Nutt.

Juncaceae
*Juncus interior Wieg.

Lamiaceae
*Hedeoma pulegioides (L.) Pers.
Prunella vulgaris lanceolata (Barton) Fernald
Teucrium canadense virginicum (L.) Eaton
Lycopus americanus Muhl.

Lythraceae
*Ammannia coccinea Rottb.

Malvaceae

Abutilon theophrasti Medic.
*Hibiscus trionum L.
Sida spinosa L.

Mimosaceae

Desmanthus illinoensis (Michx.) MacM.

Oenotheraceae

Oenothera biennis L.

Oxalidaceae

*Oxalis stricta L.

Poaceae

Digitaria sanguinalis (L.) Scop.
Echinochloa crusgalli (L.) Beauv.
*Eragrostis capillaris (L.) Nees.
Eragrostis cilianensis (All.) Link.
*Eragrostis hypnoides (Lam.) B.S.P.
*Leersia oryzoides (L.) Swartz.
Panicum capillare L.
Setaria lutescens (Weigel) Hubbard

Polygonaceae

*Polygonum aviculare angustissimum Meisn.
Polygonum buxiforme Small
Polygonum coccineum pratincolum (Greene) Stanford
*Polygonum hydropiperoides Michx.
Polygonum lapathifolium L.
*Polygonum punctatum Ell.
Polygonum scandens L.
Rumex crispus L.

Portulaceae

*Portulaca oleracea L.

Potamogetonaceae

*Potamogeton americanus Cham. and Schlecht

Rosaceae

Potentilla norvegica hirsuta (Michx.) Lehm.

Salicaceae

Populus deltoides Marsh.
*Salix amygdaloides Anders.
Salix cordata Muhl.
Salix interior Rowlee
*Salix nigra Marsh

Scrophulariaceae

*Leucospora multifida (Michx.) Nutt.
*Lindernia anagallidea (Michx.) Pennell.
*Veronica peregrina L.

Solanaceae

Datura stramonium L.
Solanum carolinense L.
Solanum nigrum L.
Solanum rostratum Dunal.

Typhaceae

Typha latifolia L.

Ulmaceae

Ulmus americana L.

Verbenaceae

Lippia lanceolata recognita Fernald and Griscom
Verbena bracteata Lag. and Rodr.
Verbena urticifolia L.

Micro-Wave Phenomena

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The purpose of this paper is to bring to the attention of those teaching courses in physical optics some of the equipment which has been developed to facilitate the process. C. L. Andrews* has previously described methods of showing light phenomena with the aid of micro-waves techniques.* The necessary equipment may be purchased partially or wholly from the General Electric Company.

The three light phenomena considered herein are polarization, interference, and one form of diffraction. The source used here is a high frequency radio transmitter whose wave length is 10 cm., shown in Figure 1.

OSCILLATOR

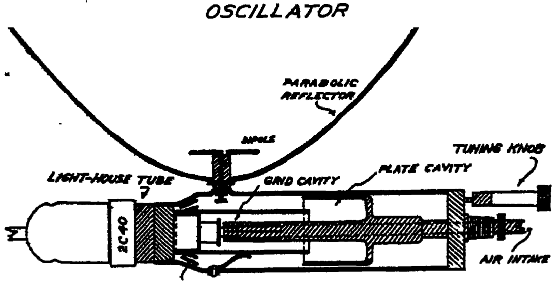
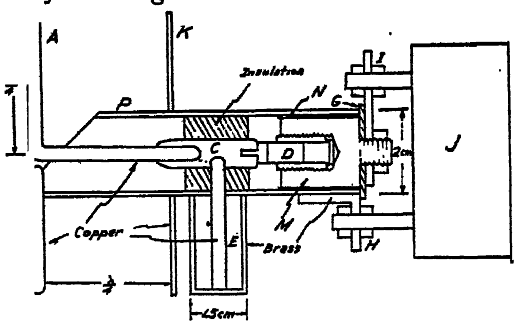


Fig. 1.

The intensity meter, which takes the place of the eye, is shown in Figure 2. Construction of both oscillator and intensity meter is amply shown by the diagrams.



A— Diapole
M—Brass Crystal Holder
D—Crystal
J—Micro-Ammeter
E— λ/4 Stub
K—Reflector
N and G —Insulator
C— Brass Cylinder
H and I — Connections
P— Hollow Cylinder

Fig. 2.

"Micro-wave Optics," C. L. Andrews, American Journal of Physics 14, 1946.

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Polarization

A very direct method of presenting polarization is shown in Figure 3. Here the dipole of both oscillator and intensity meter are horizontal; thus the radiation is polarized in a horizontal sense. A polarizing screen can be made up of copper wires stretched parallel to one another about one inch apart. When this device is placed between the oscillator and intensity meter with its wires horizontal, a minimum of energy will be transmitted. If, however, the screen is rotated through 90°, a maximum of energy will be transmitted.

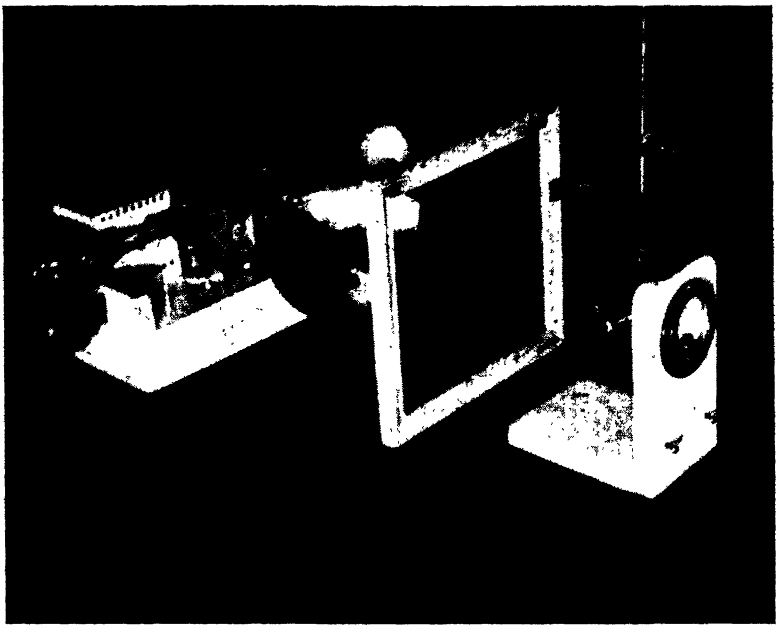

Fig. 3.

Interference

Michelson's Interferometer is an instrument used to measure the wave length of light. The principle of the interferometer can be well demonstrated by using micro-waves. Figure 4 shows the set-up of Michelson's Interferometer adapted for micro-waves. One can see from the picture the relative positions of the source, receiver, half-transmitting and half-reflecting mirror, stationary mirror, and the sliding mirror. The latter two mirrors are made of sheet aluminum, and the half-transmitting and half-reflecting mirror is constructed from two inch mesh chicken wire.

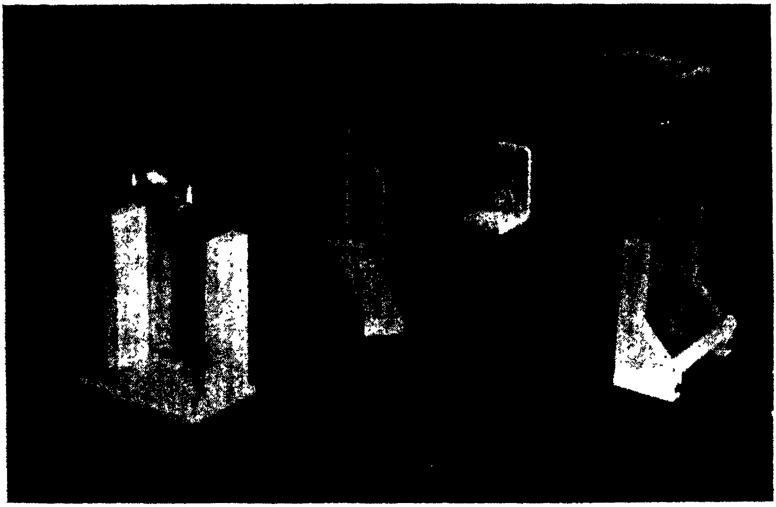

Fig. 4.

The operation of this interferometer is identical to that of Michelson's Interferometer; that is, the phase shift of the two independent sources incident on the meter is changed by moving the sliding mirror back. The meter will fluxuate from a maximum to a minimum and back to a maximum as the sliding mirror is moved back one-half wave length. Figure 5 is a graph of the data taken for the distance that the sliding mirror is moved versus the intensity meter reading. Close examination of this graph reveals that minima occur every five centimeters which is one-half of the wave length of the oscillator.

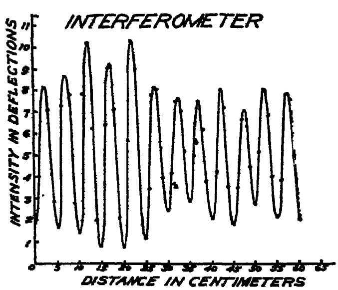

Fig. 5.

Not only does this set-up of the interferometer simplify the study of interference, but it may also be used as a means of measuring the wave length of a high frequency oscillator.*

Diffraction

Diffraction is a phenomenum due to interference of different portions of the same wave front emanating from a common source.

Experimentally this amounts to showing that light, in traveling, actually is bent around corners.

When light is incident upon a small circular aperature, the interference is demonstrated at some distance from the opening by the diffraction pattern produced on a screen. On the micro-wave basis of demonstrating this, a large hole is cut in a sheet of aluminum to serve as an aperature, Figure 6.

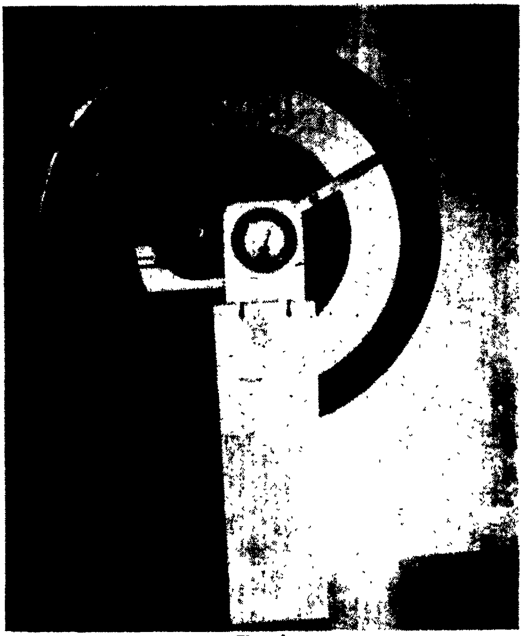

Fig. 6.

If proper distances are chosen for the location of the receiver with respect to the aperature, the hole in the metal will be the right size to act as three zones of radiating surface. These three zones, or zone plates, are indicated as (a), (b), and (c) in the Figure 7. With all three plates removed, one gets a minimum of energy detected when the receiver is twenty-five centimeters from the aperature. This occurs because the radiation from zone (b) is interfering with that from the other two zones. Now if a metal plate is placed to block out the radiation from zone (b), one observes a maximum at the same twenty-five centimeter position. From Figure 7 one may note the demensions of the apparatus used. Figure 6 is a picture of the latter condition described above; that is, with plate (b) in position and a maximum reading of the meter.

*A New Method of Frequency Measurements Q. S. T. R. Gladfelter, October, 1948.

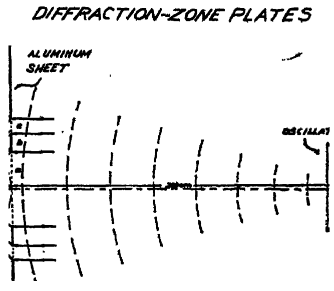

Fig. 7.

Figure 7 shows the plane wave fronts incident on the aperature with plate (b) in position. The radiation received corresponding to Figure 7 is shown in the solid-line graph of Figure 8. With plate (b) out, in Figure 7, the corresponding effect is represented by the dotted-line graph of Figure 8. From Figure 7 a maximum should occur at twenty-five centimeters, and this can be seen by reference to the curve in Figure 8.

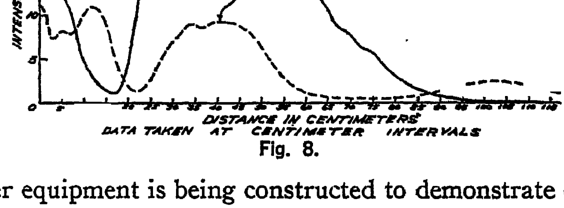

Fig. 8.

Other equipment is being constructed to demonstrate other light phenomena, but as one might suspect the parabolic mirror and dipole radiator do not constitute a point source.

Laboratory Synthesis of 2, 4 Dichlorophenoxyacetic Acid from Urea

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The synthesis of 2, 4, dichlorophenoxyacetic acid from readily available substance does not appear in the literature. It was therefore considered as a possible problem for senior research as the recent interest in the substance makes it valuable as a preparation in the elementary organic chemistry laboratory.

In an article by Pokorny, a synthesis of 2, 4, dichlorophenoxyacetic acid from 2, 4 dichlorophenol was found.[3] M. V. Likhosterstov, a Russian, found that dichlorourea was an excellent reagent for the preparation of 2, 4 dichlorophenol.[4] Further literature search revealed that Chattaway had prepared dichlorourea and isolated it as a white crystalline solid.[5] Following these investigators, our plan was to chlorinate urea forming dichlorourea, react this substance with phenol to obtain 2, 4 dichlorophenol, then to add the 2, 4 dichlorophenol to monochloroacetic acid in the presence of sodium hydroxide, and later to acidify with hydrochloric acid producing the 2, 4 dichlorophenoxyacetic acid.

Experimental

Twenty-five grams of urea was dissolved in 100ml. of water, The chlorine was passed into the solution at a moderate rate until the solution, which originally had no color, became yellow and began to give free chlorine. If acetic acid is added to the water solution before chlorination, dichlorourea precipitates as a white chystalline product. The yield for this step is 25% of the theoretical,giving 13 grams of dichlorourea. The crystalline product decomposes at 82°C.

Another method which can be used is to chlorinate phenol directly, keeping the temperature at 60°C. The Russian chemists who reported this method claim 80% yields of 2,4 dichlorophenol.[6] Careful fractionation is required.

The second step, if one is to proceed from urea, is to mix 13 grams of dichlorourea with 9.4 grams of phenol in 100 ml. of water. With the addition of 10 ml. of concentrated hydrochloric acid, considerable heat is evolved and the solution takes on a purple color. The solution is shaken for one-half hour and the oil which separates from

the solution is removed. The solution, after the removal of oil, is extracted with ether. The ether is then removed. The 2,4 dichlorophenol is obtained by fractionation of the combined oily portions. The fraction between 205°-210°C is collected. A yield of 16 grams of product is obtained which is a yield of about 97%.

The last step requires that for every 5 grams of 2,4 dichlorophenol, 2.9 grams of monochloroacetic acid be heated with 2.7 grams of sodium hydroxide in 15 ml. of water. After the reaction is complete the mixture is dissolved in 100 ml. of water. The solution is cooled to room temperature and acidified with hydrochloric acid. A heavy oil separates out which soon crystallizes. The mixture is extracted with ether and the ether extract evaporated to a small volume on the water bath. The 2,4 dichlorophenoxyacetic acid then crystallizes out. The yield of 2,4 dichlorophenoxyacetic acid is 5.9 grams for each 5 grams of 2,4 dichlorophenol used; a yield of 87%.

2,4 dichlorophenoxyacetic acid can be recrystallized from benzene. It has a melting point of 135.5°-138° C. An Eastman Kodak product had a melting point of 123°-130° C. The Dow Chemical Co. has a product with a melting point of 129° C. The substance is a white crystalline substance almost insoluble in water. The butyl esters are generally used for water solutions.

Summary

1. This method of preparing 2,4 dichlorophenoxyacetic acid, commonly called 2,4 D, is such that it can be done by organic chemistry students without trouble.

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Validity of Personality And Interest Tests In Selection And Placement Situations

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In recent months several psychology students have come to the writer seeking explanations of statements made by a psychology instructor to the effect that "personality tests are not worth the paper they are printed on", "a ten-minute interview will tell more than a test like the————test" and "these tests are useful in the hands of a skilled clinician, but have no place in the field of selection or placement." To answer their requests for information about such tests it has been necessary to bring together some of the material that will be discussed in this paper.

Some of the error for this type of teaching is traceable to the reluctance of some workers to publish the validity data which they uncover. The rest of it lies with the instructor, since the literature on the subject is growing and the preponderance of it now seems to bear toward greater and better use of both the tests of personality and interests. The teaching to which this writer has been exposed always stressed that personality and interest tests, if proved valid in a good experimental situation, were as useful as any selection or placement instrument.

The appraisal of a psychological instrument must take into account its comparative as well as its intrinsic value in selecting or placing a human being at a life task. If the instrument performs better than chance it has some usefulness. If it is better than some other instrument—such as an interview—it should have its rightful position ahead of the instrument that is less effective.

On a comparative basis with other instruments such as interviews, cumulative histories, etc., it is the experience of our firm that these tests give greater reliability and validity than any instruments except tests of mental efficiency, dexterity and other basic tests. Today we would be unwilling to risk the predictions we have to make for our clients without the use of some one of the personality or interest tests which we employ regularly.

This paper is the introduction to a series of papers of more purely quantitative nature. Several studies are completed and several more are in process. Our experience prompts us to express the opinion that tests, including those of personality and interests, are almost

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invariably more reliable, more objective, more comparable and more valid than an interview—even when the interview is conducted by an "expert". The reasons for this opinion follow.

Personality Tests

Since December, 1940, the writer has seen the use of personality tests in the selection and placement of more than 12,000 persons. Nearly all of these persons were given the Bernreuter Personality Inventory under a special form of administration designed for this especial purpose. The Bell Adjustment Inventory has been employed, along with one or two other personality tests used experimentally but not adopted for regular or general use. About 1,000 persons have been given the Minnesota Multiphasic Personality Inventory.

Reliabilities for the Bernreuter have been shown as high as .93, though we have found reliabilities as low as .81. The higher reliabilities showed in re-testing after short periods of elapsed time, the lowest came in a re-test experiment in which four months had intervened.

A study of 1,161 applicants for factory work in 1942 showed that there was a slight shift in the mean of the scores when the group was divided into four zones by the scores earned on a mental efficiency test. Those with higher scores on the mental efficiency test showed means which shifted toward better adjustment and greater social aggressiveness or "dominance". For the highest group on the mental efficiency test, however, the range of scores was just as great as for the lowest. In this study there appears to be evidence that the shift in the mean was actually due to the greater capacity of these persons of higher mental efficiency scores to adjust to their enviroment.

We have conducted many validity studies of the Bernreuter, using both correlational and differential analysis as validation techniques. We have had correlations as high as .66 in the validation of a single scale of this test! And, it must be pointed out, this validity coefficient was against a completely objective performance criterion—actual production of a group of factory workers. We have had other validity coefficients down to .30 which we still use. For factory leaders, a special scoring of the Bernreuter yields a validity coefficient of .36. What is even more important, these coefficients were found to be existing in independence of other tests in the battery with a minimum of overlapping. Stated another way, even with low coefficients of correlation existing between the Bernreuter scores and the variable to be predicted, the Bernreuter still increased the predictive power of

the combined battery because it did not correlate highly with the other tests.

One study showed the Bernreuter with considerable power to predict accident proneness, but this data must be expanded to more cases before any generalization can be made.

Validity data for the Bernreuter include a large number of tasks with which we have worked. Commercial artists, factory leaders, several factory tasks, salesmen of several types and levels, design engineers, executives and insurance adjusters are among these.

In short, we have found this test the kind which helps our clients to keep from making mistakes and to make the most advantageous placement of applicants when included with a battery of other tests.

Similarly, the Minnesota Multiphasic Personality Inventory has proved itself the answer to many problems which interviews here consistently failed to solve. Our best validation studies of the test are those in which a group profile is established by research. Certain "peaks" and "valleys" in the profile are checked by analysis of the stability of the means and where statistical differences are found that earn our confidence we find that applicants with similar profiles fit well into the group from which the data were obtained. Where "peaks" or "valleys" are due to chance we ignore them unless scores into the critical zones on the author's standard norms are found.

It is difficult to appraise a test of the type of the Minnesota Multiphasic by correlational methods. However, an even better type of validation of this type instrument comes when a staff follows as best it can the behavior of large numbers of persons to see if actual happenings affirm the test finding. Out of approximately 1,000 persons tested we now have about 32 cases in which the unusual behavior predicted by this test has actually become so evident that hospitalization, conviction of a crime or other overt validation has taken place. These were of persons who score past the author's critical score of 70 on one scale or another, but always on a scale which would have matched the diagnosis that has been made by society, by a doctor or clinical psychologist.

Our data on the Minnesota Multiphasic are weak in one respect. We are unable to follow all of the cases since we process so many. We have one other type of validation which deserves mention, however.

Early in our use of this test we began the practice of making more detailed search into the background of the individual when the test gave us a warning signal. Ordinarily, a searching character

study is too expensive and consumes too much time. Today, when we have a person with a very high score on some scale of this test we go to great length to affirm or disaffirm the findings in the individual's past behavior. This has proved fruitful—both in discovering criminal histories, overt flaunting of the social mores, alcholism and dishonesty as well as in discovering earlier breaks from normal behavior in the general classification of psychosis.

A later paper will match Minnesota Multiphasic case histories to the profiles established to show how it is that the test is validating itself as a screening device to protect industry against persons of palpably abnormal behavior.

Within the limits of the normal range of scores, however, we are finding differential validity which helps in placement. Commercial artists, design engineers, insurance adjusters and salesmen are among the groups which have established a profile pattern on the test.

Interest Tests

The particular interest test which we have used is the Strong Vocational Interest Blank (both for Men and for Women). We have had validity coefficients of this blank up to .60 for certain scales. Moreover, the test has showed itself prominently in multiple correlations as the test deserving the heaviest weighting. Combinations of two or more scales frequently prove useful in prediction.

The statement often made that the test is not useful without the cooperation of the subject is hardly true unless one considers cooperation as the willingness to make the responses called for. Actually, one study which we have completed shows that the test is quite free from the influence of the effort of the subject to make himself out as having the interest of any occupation he chooses. In one experimental situation, men who had the best of access to a knowledge of the interests of their superiors failed to bring their average score up to within one standard deviation of the mean score established by a group of their superiors. The actual difference was over 3½ times the standard error of the difference of these means.

Studies of re-test reliability with lengthy periods of time (one to three years) intervening, tend to establish the author's earlier research showing that an interest pattern strengthens when the person is actually engaged in the task. Thus the full use of the test must take into account that an interest of the same quantative level in a field which the subject has not experienced is actually greater than that level in a field in which he has experience. Of a study made of

executives, however, it was found that poor adjustment scores matched up with the men who were working in a field other than that for which they had the highest interest score. Moreover, these were mainly executives who fell below average in ratings by their superiors. In several cases in which transfers were effected, rapid and noticeable improvement both in adjustment and in effectiveness took place.

Validation of the test has been made in many situations. Among them are studies of commercial artists, insurance adjusters, salesmen, sales managers, design engineers, factory leaders, executives and accountants.

Conclusions

When used properly and in accordance with good experimental research method, tests of both personality and interests can be very useful in selection and placement. They fill a need that can be satisfied by no other instruments or technique as well.

The Professional Knowledge Of Secondary School Counselors: Its Measurement and Significance

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Increased emphasis in the last forty years upon the competent counselor and his work has created a need for a greater understanding of his personal and professional qualifications. Some research has been carried on in an attempt to discover the characteristics of the competent counselor. The various authorities in the field of guidance and counseling have been, however, in only fair agreement. In spite of those seeming differences, the importance of the counselor's professional training and experience has been emphasized again and again as one of the bases of competence in counseling. On this premise, serious scholars have been seeking answers to such questions as: What should be included in the professional training of the counselor? What is the relationship of professional training to competence in counseling? What should be the bases for the certification of counselors? Both interest and effort are today apparent in the search for answers to these and other similar questions.

The Problem

The basic assumption of this study has been that the professional knowledge possessed by the counselor is one of his important qualifications. This knowledge is normally obtained through his training and experience. Since there are many phases of counseling emphasis to be considered, some delimitation of the area of counseling was necessary. Therefore, the problem of this study may be thought of as concerned with the measurement of the professional knowledge possessed by secondary school counselors. The problem, of necessity, involved four general emphases: (1) the delineation of the areas of professional knowledge which were to be measured; (2) the formation of those concepts or principles which were considered basic to the guidance point of view in these areas; (3) the construction of test questions based upon these concepts of guidance; and (4) the refining of such a measurement of professional knowledge of secondary school counselors.

The Method

The first step in constructing a measurement of the professional knowledge of secondary school counselors was to determine the areas to be measured. The basis of organization was found in the reports

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of the National Conferences sponsored by the U. S. Office of Education through the Occupational Information and Guidance Service and the Division of Higher Education. Early in 1945, the U. S. Office of Education developed plans for two conferences, both based upon the premise that all young people everywhere are entitled to counseling services. The principal issues involved the consideration of a general guidance course at the undergraduate level for all teachers in training and of a sequence of courses for the training of counselors at the graduate level. The basis of organization for the professional knowledge of secondary school counselors was taken from the composite program of suggested training for graduate counselors presented at these two conferences.

The second step involved the formation of those concepts and principles which were considered basic to an understanding of the guidance point of view. Twenty-nine representative textbooks covering the material outlined in the suggested areas of professional knowledge were selected as sources of these concepts. These resources were carefully analyzed and from such analyses basic concepts of guidance were formed.

The third step in the measurement of the professional knowledge of secondary school counselors involved the formation of actual test questions. These questions were based upon and formed from the concepts of guidance which resulted from the analysis of textbooks. They consisted of two types, true-false questions and multiple-choice questions.

The final step in the measurement of the professional knowledge of secondary school counselors involved a check on the reliability and validity of the items of the test. The reliability of the test was checked by the split-halves technique in which a correlation was carried out between the total test score on odd items and the total test score on even items of each person taking the test. The correlation thus found was .855. To check the validity of the test, it was administered to three different groups of persons: (1) a *Novice Group*, consisting of persons at the college level of educational training but with no experience or professional training in guidance or counseling; (2) a *Beginner Group*, consisting of persons at the college level of educational training and with experience in only one or two basic courses in guidance; and (3) an *Experience Group*, consisting of persons at the college level of education training and with experience in a complete professional training course for counselors. The checks on the validity of the test were made on the basis of three criteria:

(1) the careful basis of the construction of the test itself; (2) the relative standings of the total test scores obtained by each member of the three groups taking the test; and (3) a comparison of the total test scores obtained by each member of the professionally trained group with the results of a rating scale filled out by a supervisor in a position to observe each counselor at work. The validity of the test was found to be significantly high.

Conclusions

There is a definite relationship between competence in counseling and the professional knowledge possessed by secondary school counselors; that is, more effective counselors possess a greater amount and have better understanding of professional knowledge. By the terms *less effective* and *more effective* we are here referring to the lowest and highest (say twenty-five per cent). It does not follow, of course, that organized exposure or professional knowledge *per se* may be considered synonymous with effectiveness in the counseling situation. Not at all! Were such the case the selection of effective counselors would present no problem. What we are saying here is that in order to develop and realize his full potentialities, the secondary school counselor must possess that professional knowledge which results from professional training in the area of guidance and counseling. On-the-job experience in the field may of course be expected to increase in some degree the professional knowledge of the untrained counselor—perhaps even his effectiveness—but experience alone is not sufficient.

Secondary school counselors need more extensive training in the basic principles of psychology and mental hygiene. In other words, the professional training of the secondary school counselor should give him an extensive as well as a practical understanding of the psychology of human behavior and adjustment. This would seem to encompass some measure of supervised clinical experience during the counselor training period.

Secondary school counselors need to gain an understanding of the principles basic to the various techniques of counseling. Con sequent to this is the need for an understanding of the limitations and potentialities of such counseling techniques. Again this would seem to imply a need for carefully supervised experience in all types of counseling techniques during the training period.

Secondary school counselors need training in the uses and in the principles basic to statistics. Their knowledge, as meaused here, included an understanding of the selection, the administration, and

the scoring of various tests and measurements. Some understanding of their interpretation was also indicated. When it came to the knowledge which would enable them to recognize and use the basic concepts of statistics, the secondary school counselors were found wanting.

This type of measurement may well be a beginning in the movement toward the professionalization of counseling through counselor certification, just as medicine has professionalized its services through careful measurement of the knowledge possessed by those entering its ranks. We realize, of course, that professional knowledge is only one of the characteristics of the ability to counsel. But, it is objective, it can be measured, and it is related to success and competence in counseling.

As we have further experience with this measurement, we will in all probability be able to indicate a critical point below which we should discourage persons from entering counseling as a life profession. That is to say, the measurement now may be used to differentiate between the extremes of competent and incompetent counselors. With increased use may come increased effectiveness in indicating possible success as a counselor.

This measurement may serve as one basis for the evaluation of secondary school counselors on the job. This use of the measurement is enhanced by the existence of its various sections as such. That is, the individual sections of the test may be used to indicate strong and weak areas in the professional knowledge possessed by secondary school counselors, thus giving direction to workshop and inservice training programs as well as to summer school training courses. Administrators or the counselors themselves or both may in this way check the training needs of each individual counselor.

This measurement should have some application to other types of counselors and their work—social workers, industrial personnel workers, college counselors, and so forth. If not applicable as such, certainly it may well serve as a springboard to the construction of similar measurements in these areas.

Thematic Apperception Test Diagnosis of A Nazi War Criminal

(Anonymous Post-Mortem Evaluation By A Group Of Graduate Clinical Psychology Students: Problems Of Inter-Judge Consistency.)*

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INTRODUCTION

During the last decade, the Thematic Apperception Test (14), developed by Dr. Henry A. Murray and his co-workers at the Harvard Psychological Clinic, has become a widely used clinical tool. A projective technique for the investigation of phantasy material, it has been applied in the study of personality organization and expression. At the Menninger Foundation, it has also been used for many years in the differential diagnosis of psychiatric patients, as part of a diagnostic test battery. (12)

This paper is a report of certain aspects of a study undertaken to see how a group of graduate students, receiving a common general orientation in Psychoanalytic and Gestalt psychology, but without specific training in interpretation and diagnosis of this test would go about evaluating a TAT record. We were particularly interested in learning to what extent there would be consistency in their judgments, and in determining what factors would make for variability in their interpretation. In this way we hoped also to gain some knowledge of inter-judge agreement for the test.

Tomkins (15) in his review of interpreter reliability, reports correlations ranging from + .30 to + .96 in studies of inter-judge agreement. In one such study, Mayman and Kutner (11) got high correlations for a number of TAT variables, such as "identification figure," "type of press situation," "subject's empathy with the characters," "emotional involvement", etc. A similar study by Harrison and Rotter (6) found "essential concurrence in 74%" of their ratings of "emotional maturity and stability."

Our study is based on the TAT record of one subject of middle-European culture, politically prominent in the Nazi regime, and internationally conspicuous for his rabidly proclaimed social and political views. The judges were 16 graduate clinical psychology students, a larger and doubtless more diversified group, but less expert

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*Read at the meeting of the Kansas Academy of Science (Kansas Psychological Association) in Pittsburg, Kansas, on April 30, 1948.

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than the raters in the two and four judge studies reported by Tomkins. For the variables "diagnosis," "social-political views," and "cultural background" summarized in this paper we find consistency among our judges comparable to the findings of other studies for "diagnosis," but disparate results for the other two variables.

PROCEDURE

The Thematic Apperception Test protocol of the late Julius Streicher[1], most infamous anti-Semite of the Nazi regime and Nuremberg war criminal, was given anonymously to a group of sixteen graduate students of clinical psychology. Previous experience of the group in the administration and interpretation of this test was quite limited. The students were given only the following identification: name, John H; male; age 60; married; teacher; political worker; first test (cards 1 through 10, current series) administered November 8, 1945; second test (cards 11 through 20) administered November 11, 1945. They were instructed to work out a diagnostic evaluation and write a personality description of Mr. H. on the basis of his Thematic Appreciation Test stories. As a guide, an eleven point outline was suggested[2].

This paper will comment on three of these areas: (A) the psychiatric diagnosis, (B) the social-political views, and (C) the cultural background of the executed Nazi leader inferred by the students from the TAT material.

RESULTS

A: TAT Diagnosis

Diagnostic use of any psychological test is predicated primarily on its interpretation according to a commonly accepted rationale of psychodynamics and psychopathology. Within this given theoretical framework, specific test characteristics then acquire diagnostic meaning. Harrison's caution that "the analyst may project into his interpretations his own private personality theories" (4) is not an interdiction for clinical practice; for when clinicians hold the same theories of personality dynamics, comparability of diagnostic inferences will then depend largely on sensitivity of the test instrument and skill in its use.

[1]We are indebted to Dr. G. M. Gilbert for permission to use the TAT stories taken by him from Streicher while the latter was a prisoner in Nuremberg awaiting trial. The original material will be found in his forthcoming book, "Studies In Dictatorship: A Psychological Examination Of The Leaders Of Nazi Germany."

[2]1. Diagnostic Category: evidence for normality or psychopathology a) Psychiatric syndrome b) Character traits c) Formal aspects of the test: story structure, verbalization, etc. d) Content analysis: themes, resolutions, etc. 2. Personality dynamics: ego strivings, ideals, self-conceptualization. 3. Parental figures and latent fixation. 4. Emotional stability. 5.Intelligence and thought processes 6. Direction and control of aggression 7. Sexuality 8. Interpersonal relationships 9. Social and Political views 10. Personal values, ethics, morals 11. Cultural background.

Masserman and Balken (10) make qualifying remarks about present day use of diagnostic criteria, and stress the greater importance of understanding psychodynamic thought processes to be derived from the test. They formulate diagnostic indications in the TAT for oligophrenia, conversion hysteria, anxiety neurosis, obsessive-compulsive characteristics, depressives, paranoids, and schizophrenics. Rotter (13) also reports TAT indications for schizophrenia.

In his studies at Worchester State Hospital, Harrison (3) attained 82.5% correct inferences on a number of variables for forty mentally disordered patients by checking with clinical material in the case record. His diagnostic validity was 76.9%. When he eliminated cues derived from test contract with the patient and did "blind" analysis of the stories, (5) his validity index against case history material was 74.6%. The validity of his diagnoses for "major psychiatric categories" was 73.3%. Leitch and Schafer (9) at the Menninger Clinic analysed TAT stories of 15 psychotic and 15 non-psychotic children. They found conclusive diagnostic indications of disturbed thought organization, emotion and perception in 14 of the 15 psychotic cases.

An extensive presentation of rationale and diagnostic application may be found in Rapaport's treatment of the TAT. (12)

Present day psychiatric classification and diagnostic criteria are incompletely standardized. These vary among psychiatrists, psychologists, and institutions according to their concepts of normal personality functioning and boundaries, disease processes, the manisfestations of psychopathology. Thus it is not uncommon to find disagreement among the "experts." It is often hard to say whether phenomenologically they see the some mental processes and are just evaluating them differently, or whether they are in essential disagreement on the nature of the disorder present. Kelly (8), psychiatrist to the Nuremberg jail, diagnosed Streicher's anti-Semitism as a "true paranoid reaction." Gilbert (2), the psychologist who tested Streicher at Nuremberg, described him in terms of "obsessive-neurosis." In a subsequent paper by Gilbert in collaboration with Bellak (1), Streicher is regarded as a "psychopath."*

In clinical experience, certain psychological processes encompas-

*Dr. Kelley and Dr. Gilbert were kind enough to read our manuscript. Dr. Gilbert calls to our attention that his "estimate of Streicher" should read, "obsessive neurotic" with "fanatic bigotry bordering on the paranoiac," (p. 41, The Nuremberg Diary). Dr. Kelley emphasizes that the board of psychiatrists who examined Streicher had "no doubt . . . that he was a paranoid personality of paranoid reaction type." He adds, the board "would have inclined toward" considering Streicher a schizophrenic "had any deterioration been evident, but in its absence we were forced to consider Streicher as a monomanic or essential paranoid reaction pattern." Both Drs. Gilbert and Kelley stress that they prefer to avoid the term "psychopath", the latter regarding it as one of dubious diagnostic meaning, the former seeing it as "only a socially descriptive term."

sed by these diagnostic formulations are not incompatible and may exist side by side in the same person. It then becomes a matter of weighing the personality components in evaluating and summarizing the constellation into a diagnostic formula. According to our own criteria, it appears to us that the Streicher TAT stories provide evidence for two tenable diagnostic inferences capable of clinical confirmation. One is some form of paranoid condition, probably a paranoid schizophrenia. The other is a "character disorder" or psychopathic personality with conspicuous paranoid coloring. Table 1 gives the distribution of diagnoses made by a group of graduate clinical psychology students oriented in our diagnostic concepts.

Table 1. Diagnosis of Julius Streicher's TAT by 16 Graduate Clinical Psychology Students

Diagnosis	Number
Paranoid Schizophrenia	6
Chronic Paranoid Schizophrenia	2
Paranoid State	1
Neurotic Depression with Paranoid Trends	1
Neurotic Depression (possible involutional changes mentioned by 2; religious preoccupation approaching delusional intensity noted by 1)	3
Mild Depression	1
Anxiety and Depression	1
Normal—could be paranoid schizophrenia—(but compromise on obsessive-compulsive)	1
Total	16

Their conclusions ranged from "normal" through "neurotic depression" to "chronic paranoid schizophrenia." Two of those who diagnosed "neurotic depression" made passing mention of "involutional" possibilities. Fifty percent of the group made a diagnosis of "paranoid schizophrenia." Fifty-six percent diagnosed "paranoid schizophrenia" or "paranoid state," correctly giving primary diagnostic weight to the paranoid component of Streicher's personality. If we include secondary references to paranoid trends made by two students, we find that sixty-nine percent of a group of students of limited diagnostic experience with the TAT were able to discern this outstanding personality characteristic.

We conclude that outstanding personality characteristics can be readily derived by psychologists early in their experience with the TAT. In a setting of common concepts of personality organization, psychopathology, and nosology, consistent diagnostic judgments are attainable by a majority of such group.

B: TAT Judgment of Social-Political Views

Table 2 gives the distribution of social and political views attributed to the Nazi propagandist, number-one Jew-baiter, publisher of pornography, and spokesman for Aryan supremacy.

Most striking is the diversity of conclusions reached by the students. Out of fifteen characterizations, eleven different impressions

were recorded. These ranged from "reactionary Republican" and "conservative capitalist", through "middle-of-the-roader" and "liberal", to "left-wing liberal" and "disillusioned revolutionary idealist." Approximately half placed him to the right and half to the left of

Table 2. Julius Streicher's Social-Political Views Judged from his TAT by 16 Graduate Clinical Psychology Students

Social-Political Views	Number
Reactionary Republican	2
Capitalist Conservative	1
Demagogue, Contempt for Minority and Racial Groups	2
Expresses or Phantasies Proletriat Identification, but is actually Conservative, Bigoted or even Reactionary	3
Middle-Of-The-Roader	1
Liberal	1
Anti-Capitalist, for the Common Man, but shows Race Prejudice	1
Anti-Capitalist, Pro-Labor but Hates Communism	1
Left-Wing Liberal	1
Idealist, for the Masses, Revolutionary, but Disillusioned	1
Moralistic, Honest and Righteous	1
No Judgment Recorded	1
Total	16

center. Three identified him as giving lip service to, or phantasying identification with the working class, but feeling actually conservative, bigoted or even reactionary. Attempt at understanding and reconciling internal contradictions and inconsistency of attitudes in the stories thus occurred in three cases. In teaching TAT interpretation it therefore appears necessary to emphasize critical scrutiny and discrimination of incidental expression from actual values, ego-ideals and aspirations. Otherwise, isolated expressions in one or more stories tend to be taken as representative attitudes according to the interpreter's own socio-political values. This raises the question of differentiating overt from latent content, and discerning "level" of expression.

C: Cultural Background

Henry (7) used the TAT in the study of "personality structure and development in other societies." He studied American Indian children of various tribes, evaluating their stories in terms of Indian culture and tribal norms. He found that the test "provided data on some general features of the society that are operative in the formation of personality and upon the resultant psychological characteristics." His study correlated clinical, cultural and test material. It is most interesting that in our group, where the culture of the story teller remained anonymous, it was assumed that the stories were told by an American. Not one student guessed or suspected the subject's German-Nazi cultural background. Their failure to identify Nazi concepts of blood and race present in the stories suggests interesting parallels in our own democratic culture. Thus they readily found sociological correlates and current political labels to make their identi-

fications. Specifically, our findings reflect positive correlation with the individual interpreter's cultural frame of reference, social maturity and degree of political sophistication.

However, in its broader implication, the wide diversity of opinions thus obtained shows clearly how expressions of the same man can have such widely differing social and political meanings to a group of people of superior intelligence whose thinking is psychologically disciplined. Our group is also quite homogeneous, for a large majority rated themselves as liberal or to some degree "left of center." It is therefore not surprising to find that the appeal of the demagogue gains ready reception among large and diversified segments of the population intellectually less astute, and generally more naive. The politician and his program gain popular support among people of widely differing and often contradictory needs, interests and identifications, each finding in him and his words promise of self-fulfillment.

Streicher was judged as if he were an American, with the measuring rod of American values and politics. It might be expected that one acquainted with the Nazi philosophy of master race, the leader principle, blood and soil, could hardly have missed these implications in his TAT. Similar oversight resulting from definitive boundaries of one's own cultural frame of reference might occur in evaluating the test record of one belonging to an American sub-culture the psychological implications of which are not recognized and understood. Wyatt (16) has already stressed the necessity of identifying the culturally determined "popular" response to each of the TAT pictures as a prerequisite to valid interpretation; that is, distinction of the individual response from the expected or usual response for a given population.

We conclude that use of the TAT for evaluation of a subject's social-political views and cultural background requires great care and caution. The results obtained from our student group indicate that in this area their observations were in large measure reflective of their own socio-political awareness and cultural background.

SUMMARY

A study was conducted to see how a group of beginners with the test would proceed to evaluate a TAT record. The protocol of Julius Streicher was analysed anonymously by 16 graduate clinical psychology students for 11 variables. Comments are made on their judgments in three of these areas, "diagnosis", "social-political views", and "cultural background." Consistency among the interpre-

ters compares favorably with TAT inter-judge agreement studies reported by others: 69% correctly gave diagnostic consideration to the paranoid component of Streicher's personality. It is concluded that outstanding personality characteristics can readily be inferred by psychologists early in their training in the diagnostic interpretation of this test. None suspected the story teller's Nazi cultural background, and assuming him to be an American, all used socio-political values and programs in the current American scene to "categorize" Streicher's German-Nazi viewpoint. A disparity of judgements occurred ranging on the political scale from extreme right through "middle-of-the-roader" to liberal and far left. Approximately half the group placed him to the right and half to the left of center. One conclusion to be drawn is that socio-political views and foreign culture background of a subject are less readily discernible than diagnostic indications of psychopathology in the TAT.

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Minutes and Reports of the 80th Annual Meeting, Kansas Academy of Science, Pittsburg, Kansas, April 29, 30, May 1, 1948

The 80th annual meeting of the Kansas Academy of Science was held at the Kansas State Teachers College, Pittsburg, Kansas, April 29-May 1, 1948. The Executive Council consisting of J. C. Peterson (presiding), F. W. Albertson, P. S. Albright, D. J. Ameel, W. J. Baumgartner, A. C. Carpenter, S. V. Dalton, F. C. Gates, A. B. Leonard, Paul G. Murphy, and R. Taft met at 4:20 p.m., Thursday, April 29 to transact business. Discussion of the financing of the *Transactions* and of dues resulted in no motions to change.

It was voted to present a change in By-Law IV by striking out the words "president and."

It was voted to request the treasurer to make out and present a semi-annual financial report to the fall meeting of the council.

It was voted to have the membership list published in the *Transactions* at least every third year.

It was voted to have Dr. Albright ask Wichita members to work up an industrial section for the meeting at Wichita.

It was voted to transfer interest accumulated to this date, other than that from the Reagan Fund, to the General Fund.

The proposal for affiliation of the Kansas Psychological Association was considered favorably with the provisos that the K.P.A. be responsible for setting up and conducting the psychology section at each annual meeting of the Academy, which section shall be open to all interested in psychology, but that before publication of papers in the *Transactions*, the author (s) shall be members of the Academy.

The need of reinvigoration of the Junior Academy of Science was discussed at length.

At the general business meeting at 11:15 a.m. April 30, 1948, the Academy transacted the following business:

The secretary's minutes, as printed on pages 9-10 of the 1948 program, were presented and accepted.

Upon Council recommendation (see Council minutes above) it was proposed that By-Law IV be changed by striking out the words: "president and."

Upon Council recommendation, it was voted to transfer interest accumulated to date, other than that from the Reagan Fund, to the General Fund.

Reports of officers and committees were accepted as follows:

The report of the treasurer, S. V. Dalton, was presented and accepted.

The report of the auditing committee was presented by F. W. Albertson and accepted.

The report of the state aid committee was presented by W. J. Baumgartner, who called attention to the fact that the needs of the Academy have been presented to the state budget director. The report was accepted.

The report of the committee on finance and endowment was presented by F. W. Albertson and accepted.

The report of the committee on conservation and ecology was presented by W. H. Schoewe and accepted. It called attention to the work of the Kansas Association of Garden Clubs towards the establishment of Rock City as a state park; lectures on geology presented to the 4-H Club leaders in summer camp south of Junction City; and work of Smithsonian parties along the Saline river.

The report of the committee on coordination of scientific groups and public relations was presented by E. O. Deere and accepted. It stressed the need of individual contact work on the part of members.

For the research awards committee, P. S. Albright reported that in 1947 an award of $100 had been to Austin B. Williams in connection with his work on the crayfishes of Kansas and $60 to Leon Lungstrom in connection with his work on mosquitoes. This year an award of $25 has been made to L. J. Gier in connection with his work on bryophytes in Kansas and Missouri. Request was made for the power to grant additional awards, not to exceed $90. between now and the next annual meeting. The report was accepted and the power granted.

At the business meeting at 10:35 a.m. May, 1, the following additional reports were received:

The report of the Junior Academy committee was presented by J. R. Wells and accepted. The part announcing the winners in the various classes has been printed in the report of the 80th meeting.

The report of the Academy delegate was presented by F. C. Gates and accepted. It was printed on pages 235-236 of this volume of the *Transactions.*

The report of the editor was presented by Robert Taft and accepted. It called attention to the fact that volume 50 for 1947 contained 367 pages and 36 papers and now is coincident with the calendar year. He reported that certain editorials have been widely circu-

lated in the hope that the influence of the *Transactions* can be extended.

The report of the managing editor was presented by W. J. Baumgartner and accepted. It is printed on page 10 of the 1948 program.

The report of the membership committee was presented by D. J. Ameel and accepted. It is printed on page 10 of the 1948 program.

Change in By-Law IV, proposed yesterday, to strike out the words: "president and" was passed. The By-Law now reads: IV. No bill against the Academy shall be paid by the treasurer without an order signed by the secretary.

Application of the Kansas Psychological Association for affiliation with the Kansas Academy of Science was granted with the proviso that the Association be responsible for the program of the psychology section at each annual meeting of the Academy, that the section be opened to persons interested in psychology, but that consideration for publication in the *Transactions* requires membership in the Academy.

The report of the necrology committee, prepared by D. C. Schaffner, was presented and accepted. The number of deaths was very large for a single year. The following died during the year: honorary member, T. D. A. Cockerell; life members, F. B. Dains, I. D. Graham, and Grace Meeker; annual members, G. E. Abernathy, W. E. Grimes, L. E. Hudiberg, and A. E. Shirling. Notices have been printed in the Editor's page of the *Transactions* as they occur. Obituaries have been prepared and are on file in the secretary's office.

The nominating committee report was presented by R. Taft as follows:

President: F. W. Albertson, Ft. Hays Kansas State College.

President-elect: Paul G. Murphy, Kansas State Teachers College at Pittsburg.

Vice President: P. S. Albright, Wichita University.

Secretary: A. M. Guhl, Kansas State College.

Treasurer: Standlee V. Dalton, Ft. Hays Kansas State College.

Librarian: D. J. Ameel, Kansas State College.

Additional Members of the Executive Council:

A. B. Leonard, U. of Kansas.

A. C. Carpenter, Ottawa.

John C. Frye, U. of Kansas.

Associate Editors for the *Transactions* (3 year terms)

(Physics), A. B. Cardwell, Kansas State College.

(Zoology), Mary T. Harman, Kansas State College.

The report was accepted and the secretary authorized to cast a unanimous ballot for the list.

Newly elected president Albertson took the chair.

An application for the establishment of a new section, Geography, was presented by Karl Stacey. It was voted that such should be set up at the Manhattan meeting.

The report of the resolutions committee was presented by Mary T. Harman and adopted.

Meetings are scheduled for Manhattan in 1949, Wichita in 1950, Lawrence in 1951, McPherson in 1952, and Manhattan in 1953.

At the meeting of the new council at 12:45 p.m. May 1 the following action was taken:

The president was authorized to appoint Dr. Albright and the local chairman in Manhattan to have charge of a photographic exhibit in connection with the physical science teachers section.

A meeting of the Council with certain chairmen was authorized for the fall.

It was voted to allow up to $100 for the use of the Junior Academy; up to $25 for use of the state aid committee; and up to $100 for the use of the committee on conservation and ecology.

It was voted to put the membership list in charge of the Librarian.

Adjournment.

Frank C. Gates, *Secretary*

Membership of the Kansas Academy of Science

Abbreviations: The following abbreviations for institutions have been used.

U. of K.	University of Kansas
K.S.C.	Kansas State College of Agriculture and Applied Science
K.S.T.C.	Kansas State Teachers College
H.S.	High School
Jr. H.S.	Junior High School
Jr. Col.	Junior College
U. of W.	University of Wichita
W.M.U.	Washburn Municipal University

The year given indicates the time of election to membership.

Honorary Members

BARBER, MARSHALL A., PhD., 1904, U.S. Public Health Service, Michigan Ave., Kansas City, Mo.
GRIMSLEY, G. P., PhD., 1896, Geological Engineer, B.&O. R.R. Hopkins Apartments, Baltimore, Md.
McCOLLUM, E. V. ScD., 1902, Prof. Biochemistry, Johns Hopkins University, Baltimore, Md.
WAGNER, GEORGE, M. A., 1904, 1908 Indiana St., Vallejo, Calif.
RIGGS, ELMER S., M. A., 1896, Siloam Springs, Arkansas
WETMORE, ALEXANDER, PhD., 1935, Smithsonian Inst., U. S. National Museum, Washington, D. C.

Life Members

ACKERT, JAMES E., PhD., 1917, Prof. Zoology and Parasitology, K.S.C., Manhattan.
AGRELIUS, FRANK U. G., M.A., 1904, Assoc. Prof Biol., K.S.T.C., Emporia
ALLEN, HERMAN CAMP, PhD., 1904, Prof. Chemistry, U. of K., Lawrence
BARTOW, EDWARD, PhD., Sc.D., 1897, Prof. Chem. and Chem. Engineering, State Univ. Iowa, Iowa City, Ia.
BAUMGARTNER, WILLIAM J., PhD., 1904, Prof. Zoology, U. of K., Lawrence
BERRY, SISTER M. SEBSTION, A.B. 1911, Supt. Schools, St. Paul
BRANCH, HAZEL E., PhD., 1924, Prof. Zoology, U. of W., Wichita
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PETERSON, JOHN C., PhD., 1919, Prof. of Education, K.S.C., Manhattan
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WELLS, J. R., PhD., 1919, Prof. Biology, K.S.T.C., Pittsburg
WHITE, OTIS, M.S., 1939, 4415 Bayley, Wichita 9
WILLARD, JULIUS T., D. Sc., 1883, College Historian, K.S.C., Manhattan
WOOSTER, L. D., PhD., President, F.H.K.S.C., Hays
ZINSZER, HARVEY, A., PhD., 1930, Prof. and Head, Dept. Physics & Astronomy, F.H.K.S.C., Hays

Annual Members

Members who paid their 1947 dues before May 14, 1948, are indicated by an asterisk (*). The year given is that of election to membership. If two years are given, the second signifies reinstatement. All addresses are Kansas unless indicated otherwise.

*ABERNATHY, HOWARD, M.A., 1947, Principal, Jamestown H.S., Scottsville
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The Petroleum Industry In Kansas

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We are pleased to present another important chapter in the reviews of Kansas science and technology that have been appearing in the TRANSACTIONS for the past five years. The gas and petroleum industry is now a vital part of Kansas economy which has changed greatly in the last thirty years, as the reader can readily see in the review which follows. For further information concerning the author, see page 425.

—The Editor.

Introduction

Oil and Kansas have grown up together. Dating from the early 1860's, both pioneered, both developed slowly, and both experienced the vicissitudes of youth for almost 30 years. Kansas then had a land boom, which was aided by railroad building. Further stimulation in the late 1880's came from the discovery of salt and the rapid development of plants near Hutchinson. As a result, population and capital from the east came into the State at an increased rate.

Almost immediately natural gas production in southeastern Kansas began reaching important proportions, adding measurably to the industrial substance of the State. By the end of the century, oil also had become significant in the economics of Kansas. Cheap gas for fuel created an industrial development in southeastern Kansas during the first few years of the 1900's that has not been equaled in the area since.

The flush years of the 1900's were interrupted by the panic of 1907. After several uneventful years came the most important event in the State's petroleum history: discovery and development of the great Augusta and ElDorado oil pools in Butler County, 1914-1917. Oil production in the State jumped from 3 million to 45 million barrels in 4 years. Kansas was established as an oil state.

[1]Published by permission of the State Geologist of Kansas.

Petroleum development, gradual and sound since the early 1920's, is now of major importance in the life and economy of Kansas. The value of crude petroleum and natural gas compares favorably with that of wheat in Kansas. However, the growth of the petroleum industry has been so gradual and so linked with the general development of the State itself that many citizens take the oil business for granted, not consciously aware either of its bigness or of its contribution to our manner and comfort of living.

The petroleum industry of Kansas can hardly be considered as an individual, or even as a collective entity; it must be regarded as a part of a whole that has national and international dimension. Five states, including Kansas, produce about 85 per cent of the petroleum of the United States; and the United States, having the world's largest petroleum production, and also the world's largest reserves (by a small margin), dominates the international industry. Hence, in order to show the position and importance of the Kansas industry in proper perspective, it is desirable to present briefly something of the over-all importance of petroleum in the present age, and something of the world picture because of its implications in current international politics. Nor could one offer a fair concept of the importance of petroleum or of the Kansas industry without a sketch of the ever-widening uses of petroleum products. The story, therefore, is not just one of Kansas, but rather one of Kansas' part in one of the most fabulous industries of our time.

The Petroleum Industry: A Background

International aspects.—The great importance attained by petroleum and its products—both in war and in peace—could hardly have been envisioned in 1900 when oil refining was in its infancy.

The first World War was described as one of considerable mechanization; but in World War II, the opposing forces were referred to literally and accurately as mechanized armies. Liquid fuel and lubricants were as necessary for operating the land, sea, and air units as were the materials—mainly iron and steel—from which the aircraft, ships, land tanks, and other mobile weapons were fabricated. In a future war, petroleum products, it is commonly believed, will be more necessary and will be used in greater quantity than in the last because of the probable greater use of jet propulsion in aircraft.

A sudden cutting off of the supply of petroleum and its products would be of little moment to the Eskimos living in ice igloos, or to the Indians of the high Andes living in stone huts, or to a

native of the tropics living in his palm-thatched shelter. However, to us in the United States, with our high standard of living, a sudden stoppage of our supply of gasoline, natural gas, and all oil products and lubricants would practically bring chaos as soon as immediate supplies of fuel and lubricants were consumed. Automobiles, trucks, busses, ambulances, Diesel trains, and many power plants would stop; the heating (or cooling) and lighting of many homes, hospitals, public buildings, and factories would be interrupted; and machines of all kinds which require lubrication—and what machine does not?—could not run. No such tragedy is anticipated; the petroleum industry is too well organized. But consideration of such extreme conditions, although hypothetical, merely emphasizes the importance of the petroleum industry in our country.

At present the question of supplies of petroleum and its products is an important issue in the salvage and reconstruction of Europe. Without oil from the Middle East, the Marshall Plan in Europe will be seriously handicapped or might even fail. Although the United States supplies the Marshall Plan countries with a substantial quantity of petroleum products (about 135,000 barrels per day in 1947), most of their crude oil requirements normally come from the Caribbean countries—about 100,000 barrels per day in 1947. The Middle East oil fields supplied about 80,000 barrels of crude per day to the Marshall Plan countries in 1947 (Bauer, 1948).

The Middle East oil fields of Iraq and Iran are tributary to the Persian Gulf or about 1,000 air line miles from a harbor at the east end of the Mediterranean. At present, however, Middle East oil to reach the Mediterranean must travel some 3,300 miles down the Gulf of Persia, around Arabia, and through the Suez Canal. In addition to transportation costs about 17 cents per barrel in canal tolls must be added to the total shipping cost. A large capacity oil pipe line is under construction from the Iranian fields to a port on the Mediterranean, and a second pipe line about 1,000 miles long is proposed. With this easing of transport facilities—tankers are scarce—the oil companies believe they can supply Europe with enough crude to permit reconstruction. Steel for pipe lines, which must come mainly from the United States, is a present issue. Domestic consumers do not like to see steel leave this country.

Obviously, Middle East oil is an important factor in world politics just now because the oil fields contain what may prove to

be the world's largest petroleum reserves, and they are located at Russia's backdoor.

The world's petroleum reserves as currently estimated are condensed to simple but important units in Table 1, a table which reviews briefly some of the points made above.

Table 1.—Countries containing largest petroleum reserves.
(Condensed from *World Oil,* February, 1948b, p. 271)

Country	Billions of barrels	Per cent of total
United States	22	35.5
Middle East	20	32.5
Venezuela	8	13
Russia and Sakhalin	7	11
Rest of the world	5	8
World total	62	100

Petroleum production and use in the world have increased nearly eightfold in 30 years. In 1919, world demand was 1.6 million barrels per day. Twenty years later, in 1939, it was nearly 6 million barrels per day. In 1947, the demand was 8.7 million barrels per day (10 per cent greater than in 1946), and for 1951, it is expected (Bauer, 1948) to be almost 11 million barrels daily. Where does *all* this oil come from, how much is being produced, and how much is there left? The sources as well as estimates of the proven reserves as of January 1, 1948, in more detail than shown in Table 1, are given in Table 2.

Table 2.—World production and proved reserves of crude oil.
(Figures from *World Oil,* February, 1948b, p. 271)

Country and continent	1947 production, thousand barrels	Estimated proved reserves, January 1, 1948, thousand barrels	Percentage of total world reserves
North America:			
United States	1,856,107	21,718,302*	35.07
Mexico	55,917	1,058,000	1.71
Canada	7,722	200,000	0.32
Cuba	280	3,000	0.01
Total North America	1,920,026	22,979,302*	37.11
South America:			
Venezuela	435,236	8,350,000	13.49
Colombia	25,273	500,000	0.81
Argentina	21,551	275,000	0.44
Trinidad	20,260	300,000	0.49
Peru	12,803	150,000	0.24
Bolivia, Brazil, Ecuador, Chile	2,755	76,400	0.12
Total South America	517,878	9,651,400	15.59
Europe:			
U. S. S. R.	172,000	7,500,000	12.11
Roumania	28,588	475,000	0.77
Austria	6,692	70,000	0.11
Hungary	4,521	72,000	0.12
Germany	4,064	80,000	0.13
Smaller Producers	2,606	91,700	0.15
Total Europe	218,471	8,288,700	13.39

Country and continent	1947 production, thousand barrels	Estimated proved reserves, January 1, 1948, thousand barrels	Percentage of total world reserves
Africa:			
Egypt	9,627	141,000	0.23
Smaller Producers	22	500	0.00
Total Africa	9,649	141,500	0.23
Asia (Middle East):			
Iran	152,684	5,625,000	9.09
Iraq	31,834	5,000,000	8.08
Saudi Arabia	89,079	3,600,000	5.81
Kuwait	17,850	4,500,000	7.27
Bahrein	8,998	280,000	0.45
Qatar		500,000	0.81
Total Middle East	300,445	19,505,000	31.51
Asia (Far East):			
Borneo, etc.	3,710	200,000	0.32
Netherlands India	6,483	850,000	1.37
Sakhalin (U.S.S.R.)	6,800	90,000	0.15
India	2,168	35,000	0.06
Japan	1,300	32,500	0.05
Burma, China, Formosa	1,205	140,050	0.22
Total Far East	21,837	1,347,550	2.17
Total All Asia	322,282	20,852,550	33.68
Australia-New Zealand and miscellaneous	1	200	0.00
Total World	2,986,257	61,913,652*	100.00

*United States reserves indicate crude oil only; reserves of approximately 3¼ billion barrels of condensate and other natural gas liquids not included.

One of the best means of reckoning the importance of the petroleum industry is to consider its total investment in dollars. This summary by *World Oil* (1948) is given in Table 3. The two right-hand columns obviously are estimates.

Table 3.—Gross investment in the petroleum industry, in billions of dollars.

(From *World Oil*, February, 1948c, p. 78)

	End of 1946	End of 1948	1951-1952
United States	18		25.5
All other countries	9	10	14.5
Total	27	32	40.0

More than half the world's investment in petroleum is in the United States. Domestic consumption and production are almost in balance. Countries need not have large populations, mature culture, or substantial industrialization to be important producers of petroleum. However, to be a large consumer of petroleum and its products, a country needs a large population, a relatively high standard of living, and an advanced stage of industrialization. The three seem to be essential. (China and India have the population, but lack industrialization and high standards of living.) The United States and the leading countries of Europe naturally are large consumers of petroleum and its products. Probably gasoline, abund-

ant and relatively cheap in this country, may be considered our leading luxury. Certainly it has been a main force in the development and support of our highest-of-all standard of living.

The U. S. Bureau of Mines has estimated the domestic production of crude oil at 2,014,000,000 barrels in 1948, an increase from 1,856,107,000 barrels, or 8.5 per cent of the 1947 production. The United States, then, both produces and uses substantially two-thirds of the crude oil production of the world at the present time (Fig. 1). This fact, as suggested in the paragraph above, can be interpreted only in the light of the stage of industrialization and of the standard of living of inhabitants of the United States.

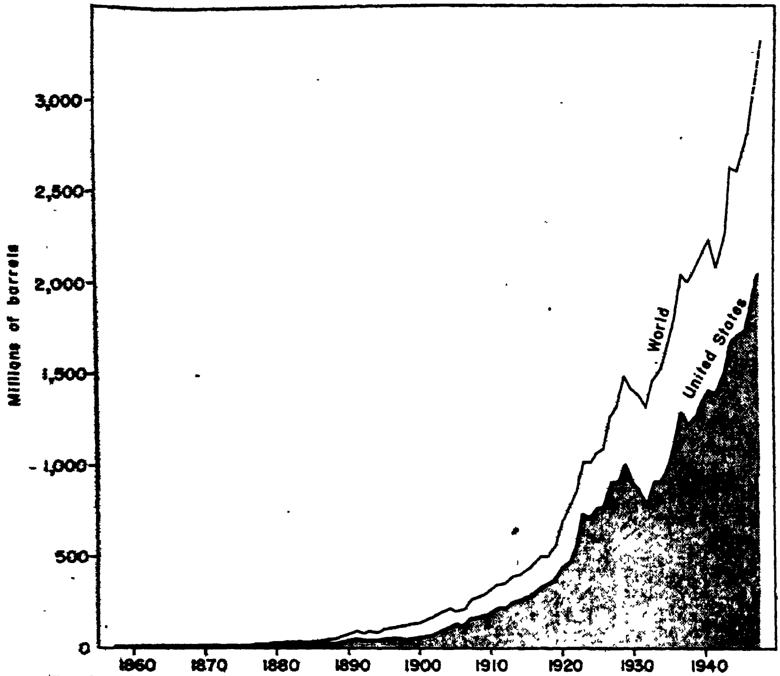

Fig. 1.—Annual production of crude oil in the United States and the world (adapted from U.S. Bureau of Mines reports).

The petroleum industry in the United States.—The story of oil in the United States is an account, which deservedly should be written in epic style, of the happenings within a fabulous industry between the year 1859 when 2 thousand barrels of oil was produced, and the year 1948 when 2 thousand *million* barrels of oil will be produced in the United States.[1]

[1]Estimate by the U. S. Bureau of Mines.

For purposes of historic reference, the domestic petroleum industry began with the completion of the famous Colonel Drake oil well near Titusville, Pennsylvania, in August, 1859. Production was obtained at a depth of 69 feet without benefit of electric logging, acidizing, drill stem tests, or knowledge of bottom hole pressure. Previous to that time, oil, used for medicinal purposes and to some extent for lubricating machinery, had been dipped or skimmed from natural springs or shallow pits, although salt wells in which oil was sometimes a nuisance commonly were drilled hundreds of feet deep. Drake contributed the original idea of casing the well by driving "an iron tube" to a depth of 36 feet into hardpan above the firm bedrock. The initial production of this original "pool opener" was 20 barrels per day and it undoubtedly was "from the Pennsylvanian," to use Kansas vernacular.

Drake fathered the idea in America of obtaining oil by drilling holes into the earth, and demonstrated the effectiveness of his method. Northwestern Pennsylvania "went wild" over oil possibilities and possible profits. If the old reports are true — as they probably are — almost the only thing that has not been changed and improved about the oil business in the 90 intervening years is the wildness of an oil boom.

The business of improving the technique of drilling holes into the earth for oil began with Drake's well and so long as there is strong demand for oil and it becomes more and more difficult and costly to develop, research will continue to find new and better ways to discover and produce it.

The United States oil industry should receive principal credit for developing both the production and refining of petroleum as it is now done in the world. Production of oil in the Baku fields of Russia and in Asia Minor, which is so old that there is Biblical record of it, was from shallow wells dug by hand until the first bored well was completed in 1871 (Thompson, 1904, quoted by Haworth, 1908, p. 9). From then on, western devices were employed to an increasing extent.

The famous oil spring at Cuba, in southern New York, was described by a French missionary in 1627. Charlevoix, describing his travels in 1721, referred to an oil spring where savages used the oil to assuage all sorts of pain. Oil Creek (Pennsylvania) was first mentioned about 1750. In 1808 petroleum was considered a nuisance in salt wells drilled in West Virginia. Some of these were alleged to have produced 25 to 50 barrels of oil per day; the oil was

allowed to flow over the top of the salt cisterns into the Kanawa River, causing boatmen to name that stream "Old Greasy." Natural gas seems first to have been used in 1821 in Fredonia, Chautauqua County, New York, for lighting houses. In 1829 the famous American salt well was drilled in Cumberland County, Kentucky. A "vein of pure oil" affording "many thousand gallons per day" was struck. The liquid flowed to the Cumberland River, became ignited, and burned on the surface of the water for a distance of about 40 miles (Derrick's Handbook of Petroleum, 1898, pp. 6, 8, and 9).

The first use of natural gas in manufacturing seems to have been by William Tomkins in 1841. Tomkins used the gas in his furnace for boiling salt brine in the Kanawa Valley in West Virginia. Perhaps the first successful oil refinery was that built in 1854 at the corner of Grant Street and Seventh Avenue in Pittsburgh, Pennsylvania. The still occupied a building about 12 by 24 feet and had a capacity not exceeding 5 barrels per day (Tenth Census of United States, Vol. 10, Special Report on Petroleum). The first oil lease on record was probably in 1853 (Derrick's Handbook of Petroleum, 1898, p. 12) and dealt with keeping in repair or digging new oil springs for a period of 5 years.

The first oil pipe line on record (Henry, 1873, p. 283) is believed to have been a line laid by Samuel Van Syckel in 1865. It was 4 miles long, and extended from Pit Hole to the railway at Miller's farm in Pennsylvania.

The first use of explosives or the first "shooting" of oil wells was in 1865 (Henry, 1873, pp. 251, 542). Col. E. A. L. Roberts fired a torpedo in a well near Titusville, Pennsylvania, to increase the flow of oil in that well.

The vast development of the petroleum industry in the United States has taken place mainly in the past 50 years, due largely to the contemporaneous development and increased use of the internal combustion engine, particularly for mobile vehicles and devices. Oil refining on a substantial scale dates from around the turn of the century. The old Standard Oil Company, dissolved in 1911 for antitrust law violations, probably was the greatest factor in developing refining methods in those early years. After the dissolution of the old Standard Oil Company, many oil companies sprang up; some of them represent multimillion dollar corporations today. Most of the large companies are fully integrated, having production, refining, transportation, and distributing facilities.

In point of rank, the petroleum industry is one of the largest in the United States. Some idea of the importance of petroleum in comparison with other domestic mineral production may be gained from Table 4. Of the total value of 8.1 billion dollars for raw or crude mineral products in the United States for 1945, almost 40 per cent (38.2) consisted of petroleum. Another comparison is indicated by Table 5. Here tonnages and corresponding values of petroleum and the leading heavy tonnage metals are compared. The tonnage of crude oil and products from natural gas commonly included with crude products is 20 per cent greater than that of iron, copper, lead, and zinc, the four leading metals, combined, and the value of the crude oil and petroleum products removed from natural gas is 5.75 times larger than the total value of the four leading metals produced.

Petroleum technology (except possibly petroleum geology about which there is some difference of opinion)* seemingly has advanced to a greater extent in the United States than elsewhere. Petroleum synthesis had gone far in Germany until recent years, but it is

Table 4.—Comparative rank of petroleum in total United States Mineral production in 1945.
(U. S. Bureau of Mines, 1947)

Item	Dollar value	Per cent of total
Nonmetallics		
Petroleum	$3,110,399,000	38.2
Coal	2,101,280,000	25.8
Total fuels	$5,211,679,000	64.0
Other nonmetallics	956,000,000	11.7
Total nonmetallics	$6,167,679,000	75.7
Metallics	1,975,000,000	24.3
Total all minerals	$8,142,679,000	100.0

Table 5.—Comparative tonnages and values of petroleum and principal metals produced in the United States, 1945.
(U. S. Bureau of Mines, 1947)

Item	Production reduced to tons of 2,000 lbs.	Value
Petroleum		
Crude oil	251,532,141	$3,110,399,000
Natural gasoline / Liquid petroleum gases	15,188,897	
Total	266,721,038	
Iron ore	98,713,000	243,760,986
Copper ore	76,856,000	184,723,000*
Zinc ore / Lead ore	36,373,000	80,338,000* / 45,636,000*
Total	211,942,000	$554,457,986

*These figures are values of the contained metal, rather than values assigned to the crude ore.

*Personal communication to the writer from a well-known American geologist after visiting and analyzing work and results of American- and European-trained oil geologists working in Venezuela.

believed that American scientists have made important strides in producing gasoline from coal and other basic organic substances. The American oil driller and production man probably has no equal anywhere in the world; and the American petroleum engineer is highly regarded everywhere for his capacity for solving tough technical problems and for making the job go.

Uses of petroleum and its products.—In the dim period before written history, the primitive peoples of the earth undoubtedly had important use for what we now call oil and gas. When history as we know it began, the early peoples were using liquid petroleum from natural springs as ointments and in various medicinal ways. Sacrificial fires, worshipped by various peoples of early times, were provided by natural gas which exuded from the ground at various points over the earth.

From that early period to the present century, no great progress was made in utilizing petroleum for the good of mankind. Then, from about 1900, the science of refining crude oil has developed from simple distillation to a complex and involved technology. Oil refining now supplies our demanding civilization with hundreds of common and necessary substances that are in everyday use. To name even a goodly percentage of these substances would be too great a task for this paper.

The U. S. Bureau of Mines, in its minerals Yearbook, published annually, divides the products from crude oil refining into these major classes: motor fuels, kerosene, distillate fuel oil, residual fuel oil, lubricating oil, wax, coke, asphalt, road oil, and other finished products. The relative amounts of each of the above classifications produced in the United States during 1945 will indicate the volumes used in this country (Table 6).

Table 6.—Refinery products in the United States—production and demand, 1945.

(U. S. Bureau of Mines, 1947, p. 1096)

	Production Thousands of barrels except as otherwise indicated	Domestic demand
Motor fuel	799,059	696,407
Kerosene	81,024	75,595
Distillate fuel oil	249,224	225,753
Residual fuel oil	469,492	523,082
Lubricating oil	41,867	35,318
Wax (thousands of pounds)	817,880	673,136
Coke (thousands of short tons)	2,023	1,841
Asphalt (thousands of short tons)	7,127	6,698
Road oil	2,686	2,505
Other finished products	19,080	36,291

From the hydrocarbon gases and light distillates come liquid petroleum gas — now becoming commonly known as LPG, including

propane, butane, etc. Also, these lighter fractions of the crude oil are converted into alcohols, aviation fuel, carbon black, esters, isopropyl ether, blending naphtha, commercial solvents, motor gasoline, tractor fuel, and the common naphthas. From the light distillates are derived, by chemical and physical processes, some of the phenols, some resins used in varnish, paint dryers, kerosene, mineral seal oil, and signal oil. The so-called intermediate refinery distillates yield gas oil used for furnaces, Diesel fuel, light industrial and metallurgical fuel, and also absorber oil. From the heavy distillates come lubricating oils, heavy oils, and waxes. From these are produced flotation oils, emulsifying oils, rustproof oils, and white oil from which medicines and cosmetics are made. The latter include creams, lotions, ointments, and salves. From the waxes a long list of compounds such as candle wax, canning wax, etchers' wax, certain insulations, and waxes used in tree grafting, waterproofing, floor polishing, and detergents are made.

Lubricating oils produced include oils for valves, turbines, transformers, gasoline motors, air filters, compressors, cup greases, water pump greases, journal compounds, steam cylinder oil, tempering oil, harness grease, and gear oils.

The refinery residues contribute a considerable list of products, including some of the lubricating oils and waxes. From residues come cable-coating compounds, metal and wire rope lubricants, antirust greases, boiler fuel, wood preservative oils, still wax for roofing materials, various types of asphalt used for boilers, road oils, roofing saturants, briquette asphalt, asphalt base paints, and paving asphalts. The so-called oxidized asphalts supply a few products such as rubber substitutes, pipe coating, roof coatings and waterproofing, and insulation asphalt. Coke briquettes, carbon brush and carbon electrode coke, and fuels are made from coke and such products as carbon blacks. Another small group of products comes from the residues called the oil soluble sodium sulphonates — the emulsifying and de-emulsifying agents.

From the refinery sludges come heavy fuel oils, sulphuric acid, sulphonic acid from which wetting agents are made, and certain minor products used in the making of soaps, wood preservatives, paint dryers, and antiseptics. Much more detailed information on uses of petroleum products is given by Shuman (1940).

During the last war much controversy developed between agricultural and petroleum groups on the question of whether butadiene for synthetic rubber should be made from petroleum or from alcohols

derived from agricultural or forest products. On a war or subsidy basis there seemed to be little to choose between the two sources; but on a basis of low-cost peace-time production, petroleum seems to be the easy winner. A high grade of synthetic rubber is now being made from petroleum at approximately the cost of natural rubber.

Petroleum is composed essentially of two very common and important chemical elements, namely, carbon and hydrogen — with some minor impurities. It has been discovered, largely in recent years, that organic products, fuels, acids, plastics, alcohols, and almost everything that contains carbon and hydrogen as basic ingredients can be made from petroleum products by breaking down the complex carbon, hydrogen, and oxygen molecules and reassembling these molecules by thermochemical means in such a way as to produce new substances. This essentially is the chemistry of some organic acids, oils, glues, and the basis for numerous paints, medicines, and other products.

It is being found now that both oil and gas are more valuable for the products they can produce than they are merely as fuel. Natural gas, particularly, has become an important source of chemicals made in costly and complex plants by breaking down the gas into its components. Natural gas can be made into the much more usable gasoline and a long list of chemicals by so-called synthesis. Estimates place our domestic gasoline demand at 860 million barrels in 1950, 965 million barrels in 1955, and more than 1 billion barrels in 1965 (Standard Oil Company of New Jersey, 1947).

The Petroleum Industry in Kansas

Introduction.—Kansas, as a petroleum or oil state, ranks fifth in the United States, a position it has maintained for the past several years. By the end of 1948, Kansas will have produced crude oil and natural gas having an estimated cumulative value of approximately 3 2/3 billion dollars of which nearly 1 billion dollars will represent natural gas. The value of crude oil and natural gas produced in Kansas during 1947 was 262 million dollars; for 1948 the amount will probably exceed 325 million dollars.

At present there are 621 oil and gas pools in Kansas. The major areas in the State where oil and gas have been or are being produced are shown in Figure 2. It should be understood, however, that only a small fraction of the total area on the map is actually producing oil or gas and that the greatest amount of territory shown by cross-hachures is unproductive and lies between producing pools.

Most oil and gas pools are small, those in western Kansas averaging about 1 square mile in area.

In the case of the Hugoton gas field, there is no oil production within the main area although two wells producing some condensate were completed near the edges of the field in 1948. The condensate comes from a much greater depth than the regular gas-producing zones in the Permian rocks.

History of oil and gas in Kansas.—Oil seeps or springs were known in the 1850's by the early settlers in what is now eastern Kansas (Haworth, 1908, p. 21). The best-known springs were located on streams called the Wea and the LaCygne in Miami County.

As early as 1860 much interest was shown in the possibilities of oil in the Kansas Territory because of the news of the drilling of the famous Colonel Drake oil well near Titusville, Pennsylvania, August, 1859. Petroleum history in the United States virtually began on that eventful date. Within a year after the completion of the Drake well, Kansas began her oil development. Dr. G. W. Brown of Lawrence, after visiting an oil spring on Wea Creek in Miami County, formed a company to explore the area for oil. In midyear 1860, he leased approximately 30,000 acres of land and "employed men with boring apparatus" to start drilling (Haworth, 1908, p. 22). This well and another located about 8 miles south were drilled to depths of about 100 feet, the limit of their drilling apparatus. Both holes were unsuccessful. A third well drilled approximately 1 mile east of Paola at the old Baptist Mission found salt water and oil. The test was drilled "over a hundred feet below the bottom of the old well" in which they had started their hole. This well, although it contained very little oil, is commonly regarded as the first producing Kansas oil well on record.

The first Kansas oil company was a war casualty. With the advent of the Civil War, the operations were interrupted; two of the instigators died; two, southern sympathizers, left the country; and the remaining founders of the company were almost ruined financially by the Quantrill raid on Lawrence in August, 1863.

There was some petroleum activity about this time in other eastern Kansas counties. In the few wells put down in Wyandotte County in the Kansas City area (Haworth, 1908, p. 26), more oil than gas was found, according to report. Little seeps of oil were known in what are now Shawnee and Bourbon Counties, and as far south as Cherokee County where a stream was named "Tar Creek" for the amount of oil present at the surface.

In the 1870's and 1880's, Paola seems to have been the oil capital of Kansas. Enough gas to supply the village was discovered in wells drilled about 7 miles northeast of town in 1882. A line was laid and the gas piped into town, the franchise dating from 1884.

Oil then sold for $3 to $5 per barrel for lubricating purposes, but there was little demand. In 1886 or immediately thereafter, the group which piped the gas into Paola sold out to the Kansas Oil and Mining Company, which began experiencing some success in producing oil and gas. This company built a small refinery (type and capacity unknown) in Paola, probably Kansas' first oil refinery.

Discovery of the Iola gas field began with the drilling of the famous Acers well in 1873. Drilling seemingly did not reach the main gas-producing formation, but both gas and mineral water were found, the latter being regarded as the more important. Even after this discovery of gas, development of the field was slow. It was not until about 20 years later, 1892-1893, that there was an abundant supply of gas in the Iola area. Industrial interests then were quick to install plants to use the cheap gas. Zinc smelters, cement plants, brick plants, and others of less importance began locating in the area in the middle 1890's.

Exploration in what later became the important Humboldt gas field began in 1894 and 1895. However, the small amount of heavy oil produced in wells drilled north of Humboldt was not regarded as worth keeping, so the early leases were abandoned.

About 1895 Chanute became the first municipality in the State to own its gas supply from wells it had drilled.

The history of petroleum development at Independence began in 1884 when Dr. B. F. Masterson of Independence raised funds and drilled a well near town in search of coal, two veins of which had been discovered in the vicinity a dozen years before. At 1,200 feet the well blew in, making both gas and oil. The oil ran along the ground to a point near the boiler, ignited, and burned everything combustible about the place (Haworth, 1908, p. 35). Even with this beginning, gas in quantity was not developed at Independence until the summer of 1893. Large gas production in the area did not come until the Bolton field was discovered in 1902. In that year and the next, oil production in the same field attained an important rate, some wells coming in with initial capacities as high as 1,000 barrels of oil per day.

The oil fields of Chautauqua County also began production in 1903.

In Kansas the transition in public demand from natural gas to oil began in the middle 1890's. Before that time, there was little demand for oil, whereas natural gas had a ready sale for domestic and industrial use. A development that markedly increased the demand for oil in southeastern Kansas was the building of a refinery at Neodesha by the Standard Oil Company in 1897 (Personal communication from R. D. Williams, the Standard Oil Company). The refinery offered a market within a fairly wide transportation area for oil which formerly had but meager outlet. Even so, oil development was slow. Table 7 shows the number of producing wells in Kansas at the close of each year from 1897 to 1903, and Table 8 presents salient details of the petroleum industry in Kansas for the years 1903-1908.

Table 7.—Producing oil wells in Kansas 1897-1903*.
(Oliphant, 1904, p. 666)

Year	Number of producing wells
1897	71
1898	86
1899	85
1900	108
1901	160
1902	391
1903	1,145

*Oil wells included in the figures for 1903 are understood to be those connected to a pipe line. Of the 1,145 producing wells in the State in 1903, 478 were in Neosho County, where oil activity centered.

Table 8.—Salient Kansas petroleum statistics, 1903-1908.
(U. S. Geol. Survey, Mineral Resources of United States, 1904-1909)

Year	Wells Completed	Crude oil production, bbls.	Value of crude oil	Price per bbl., year average	Nat. gas production 100 M.cu. ft.	Value	Price per M. cu. ft.
1903	1,224	932,214	$ 988,220	$1.20*a*	---- ----	$1,123,849	-- ---
1904	2,782	4,250,779*b*	5,447,622*b*	0.97	81,805	1,517,643	1.85c
1905	1,518	12,013,495*b*	6,546,398*b*	0.547	---- ----	2,261,836	-- ---
1906	700*c*	21,718,648*b*	-- ---- ----	0.443	69,323	4,010,986	5.8 c
1907	423	2,409,621	965,134	0.402	76,707	6,198,583	8.1 c
1908	566	1,801,781	746,695	0.414	80,740	7,691,587	9.5 c

a Weighted average calculated from data given in Table 9 below and represents the composite average for the year.
b Figures include total production and total value of crude oil for Kansas and the Indian and Oklahoma Territories.
c Figure is estimated.

The production of crude oil during 1903 by districts (Table 9) shows clearly where most of the Kansas oil interest centered. According to Oliphant (1904, p. 663) the Kansas area topped any other area in the United States in oil activity in 1903.

Table 9.—Kansas oil production by districts, 1903.
(Oliphant, 1904, pp. 666, 668)

District	Production, bbls.	Price, per bbl., at year's end
Chanute	560,001	$1.16
Independence	143,912	1.36
Neodesha	111,525	1.36
Peru	63,614	1.36
Humboldt	40,025	.60
Cherryvale	13,137	1.36
Total	932,214	$1.20 (weighted average)

From the data in Table 8 one would conclude that production of both oil and gas was leveling off for the years 1906-1908. Actually oil production did drop somewhat, and did not again exceed the 1904-1906 average until 1916 when Kansas oil production skyrocketed on account of the fast-developing Augusta and ElDorado pools. Gas production, which reached a crest of 80 billion cubic feet in 1908, dropped to 22 billion cubic feet in 1913 and 1914 and to 14 billion in 1919. It was not until 1937 that gas production in Kansas again passed the 80 billion mark owing to the increased production of the Hugoton field in southwestern Kansas.

The effect of large quantities of cheap gas for fuel on the industrial development of southeastern Kansas was very marked even in that early period, as shown by Oliphant (1904, p. 738), and presented in Table 10.

Table 10.—Users of Kansas natural gas, 1903.
(Oliphant, 1904, p. 738)

Users	Year 1903
Domestic customers served	15,918
Zinc smelters supplied	11
Glassworks supplied	3
Brick plants supplied	14
Other establishments supplied	113

By 1905, the number of glassworks in southeastern Kansas supplied with natural gas had increased to 20, the number of brick plants had increased to 33, and other establishments served with gas to 527. At the peak there were nine zinc smelters within a 5-mile radius of Iola, an area which is reported (Iola Register, October 25, 1947) to have constituted the largest concentration of zinc smelting in the world at that time.

However happy the people of southeastern Kansas were with the increase of industrialization and with the evidences of prosperity about them, they were constantly aware of the difficulties of the oil producers. Judging by the columnage in the daily papers of the times and by the asperity of the editorial comment, most citizens of the area were not pleased with the low price paid for crude oil. It seems that the Standard Oil Company either directly or through a subsidiary, the Prairie Oil and Gas Company, virtually controlled the purchase of crude oil for refining in Kansas. Sentiment became so strong in the State that the legislature passed a bill to establish an oil refinery at State expense at Peru, Kansas. The refinery was to be operated by a branch of the State penitentiary to be built nearby and $410,000 was appropriated, $210,000 for buildings and plants and $200,000 for revolving fund. The law was directed against alleged monopoly by the Standard Oil Company because of the low

buying price for oil, and presumably to give an independent outlet for crude to Kansas producers. (The Chanute Tribune of February 15, 1905, carried the headline, "It Passes Three to One." The next day, February 16, 1905, the bill was signed by Governor Hoch, who let the people and the press know his conviction that Kansas would take care of her own.) But on July 7 of the same year, 1905, the State Supreme Court declared the refinery law unconstitutional. According to the report (December, 1905) of the State Oil Inspector there were five independent oil refineries operating in the State in 1905.

An interesting page from the history of the times was the starting in the same month, July, 1905, by the Atchison, Topeka and Santa Fe Railroad Company of its *Oil Flyer* train between Chanute and Tulsa. It was said to have been the first train in the midwest pulled by an oil-fired locomotive. Much local fanfare accompanied the train's debut. According to the Chanute Tribune, issue of July 25, 1905, "It is called the 'Oil Flyer' because it travels through Kansas and Indian Territory oil territory every foot of its journey." The *Oil Flyer* is still running.

Prices of crude oil for those first years of the century were low indeed, as indicated by Table 8. When the price dropped below one dollar per barrel, the effect was immediately indicated in the number of wells completed. In May, 1905 (Chanute Tribune, May 27, 1905), the buying price advertised by the Prairie Oil and Gas Company locally was: 30° to 30½° Baume', 33 cents per barrel; above 32° Baume', 53 cents per barrel; and below 30° Baume', not purchased.

On September 12, 1905, the *Chanute Tribune* headlined, "The Price Goes Up At Last." Then followed the statement, "The Standard today announced a raise in the price of all grades of oil testing below 32° . . . Oil below 30, denominated by the Standard as heavy in fuel oil, is quoted at 30 cents, an increase of 5 cents over the former price." (The lower gravity oil had been accepted again since about June 1 of that year, at about 25 cents a barrel).

The schedule of buying prices for Kansas crude published in late September, 1905, is given in Table 11.

Table 11.—Kansas crude oil prices, September, 1905.
(Chanute Tribune, September 28, 1905)

Grade	Price, bbl.
Heavy oil	$0.35
30° (Be.)	0.39
30½° (Be.)	0.42
31° (Be.)	0.45
31½° (Be.)	0.48
32° and above	0.51

No outstanding petroleum discoveries or developments in areas

outside southeastern Kansas took place for a dozen years after the turn of the century. Both oil and gas fields were extended in southeastern Kansas and many dry holes were drilled in unproductive counties farther west. This period seemingly marked the beginning of the concept that oil and gas commonly occur in domes and anticlinal structures. Producing companies began to be "geology conscious." "Rock hounds" with tight breeches and secretive manner became common sights on the ledges, hills, and slopes of central and southeast Kansas. "Anticline," "dome," "duster," and "lease hound" became household words as common in the vernacular as chinch bugs and "white faces." Gas production in the Iola-Neodesha-Cherryvale-Fort Scott area was diminishing and the industrial activity was easing off necessarily.

Then occurred a development that probably was the most important one in Kansas petroleum history: the bringing in of the Augusta oil pool in July, 1914, and the ElDorado oil pool in October, 1915 (Fath, 1921, p. 19). These fields were found on the so-called granite ridge which crosses eastern Kansas somewhat obliquely from Nemaha County on the north through Cowley County on the south. This discovery, incidentally, or at least the discovery of the ElDorado pool, can be credited to geologic effort, and to one man, Erasmus Haworth, then State Geologist of Kansas. Haworth (Moore and Haynes, 1917, p. 21) credits N. A. Yeager, an Augusta attorney, with responsibility for the early gas development in the Augusta area. Whether Yeager was responsible also for finding the first oil at Augusta, in 1914, is not clear but it seems quite likely. At any rate, Haworth and his son, Huntsman Haworth, were employed in 1912 by the Kansas Natural Gas Company to find promising gas territory. As a result of their investigations they recommended to their clients in September, 1912, that leases be obtained west of ElDorado where they had discovered a promising anticlinal structure. The advice seemingly was not acted upon. In 1914, according to Haworth's statement, the city council of ElDorado asked for help in locating natural gas deposits. The first hole, located in sec. 1, T. 26 S., R. 4 E. which is not far from the heart of the present ElDorado field, was dry. Soon, the Wichita Natural Gas Company (later to become the Empire Gas and Fuel Company) took over the properties from the city of ElDorado, and drilled the field opener, the Stapleton well, in sec. 29, T. 25 S., R. 5 E. Two shallow sands, one at 590 feet and one at 670 feet, were productive, making a 150-barrel well. This pay was mudded off

and the well deepened to another sand at 2,465 feet, later to be called the "Stapleton pay," where production of about 175 barrels per day was obtained. Development of what is now called the ElDorado field dates back to this well.

An oil boom of major proportions was touched off by the coming in of wells at 1,000 barrels per day and more at considerable distances from the discovery well. The famous Trapshooter gusher, brought in early in June, 1917, in sec. 11, T. 26 S., R. 4 E., was estimated to have had an initial capacity of about 14,000 barrels of oil per day. A little later (September 7, 1917), the Gypsy Oil Company's equally famous Shumway well was completed in the same section. With a string of tools in the hole, that well came in making nearly 20,000 barrels of oil. By Christmas it had declined to about 10,000 barrels per day. After removal of the tools it increased to about 14,000 barrels. In the 222 days of the flowing life of this well, it produced about 2,500,000 barrels of oil. Fath in 1921 (p. 23) wrote that it "was not only the most prolific well in the ElDorado pool, but probably produced more oil than any other well ever drilled in the Mid-Continent field." At the present time the ElDorado field covers some 40 sections of land. It can be called Kansas' greatest oil field by virtue of its having produced a total of 195,591,000 barrels of oil since discovery, or more than twice the amount of oil produced by any other pool or field in the State. It is still a large producer (2,764,000 barrels in 1947), and although located in eastern Kansas, it can hardly be classed as a "stripper" field in spite of its age, 33 years.

Figure 8 (see page 406) shows plainly the effect of the development of the Augusta and ElDorado fields. From an average of less than 3 million barrels of oil per year, the State's production jumped suddenly in 1916 to 8 million barrels, then to 36 million barrels in 1917, and to 45 million barrels in 1918. In the 29 years since that time, the oil production of the State has averaged 57 million barrels annually. This last figure, however, is hardly a true measure of the situation, because two distinct periods and sets of conditions prevailed. The first 22 years, from 1918 until 1941, contained a post-war period of several years after the first World War, which was followed by a period of great industrial activity and expansion continuing until the financial crisis of 1929. The interval following the dozen years previous to World War II, consisted mainly of the depression years of the 1930's. During these 22 years, the average annual production of the State was 44 million barrels. The war

years, beginning with 1941, were marked by very great oil production, urged by both State and Federal agencies, and encouraged by satisfactory prices for the products. Kansas oil production for the years 1941-1947 inclusive, averaged more than 97 million barrels annually.

From 1918 until the present, the center of oil activity in the State has moved generally westward, or, more accurately, northwestward from Butler County. This movement has coincided with the development of oil pools on the Central Kansas uplift reaching from Sedgwick through Harvey, Reno, Rice, Barton, Ellsworth, Russell, Ellis, and Rooks Counties. While that significant development was taking place, the importance of oil and gas production in the southeastern counties gradually waned.

Nothing can detract, however, from the part played by the southeastern Kansas counties from the days of the very beginning of the petroleum industry, well into the 1920's, after Kansas had "arrived" as one of the leading oil-producing states of the nation. The years from the middle 1890's, when the Iola-Chanute-Independence natural gas area began its ascendancy, up into the 1920's constituted the rugged, adolescent period of the State's petroleum industry. Those 30 years corresponded—although in a more subdued manner — with the lurid days of the "roarin' west" of the California and Nevada gold camps.

The first important oil pool in western Kansas was discovered in Russell County in 1923. The Valerius Oil and Gas Company drilled a test well in sec. 8, T. 12 S., R. 15 W., on an anticline that is visible in the surface rocks. There was no oil production at that time closer than ElDorado in Butler County, more than 100 miles away. The first producing well in the area, later to be called the Fairport pool, was drilled on the Oswald farm. For that reason, the producing zone was named the "Oswald." The name has persisted until this day, although it is now known that the "Oswald" zone or zones are layers of limestone within the 250-foot sequence of the Lansing, Kansas City, and Bronson beds. It was later found that nine such zones were productive in the Fairport pool. Since discovery, the Fairport pool has produced almost 20 million barrels of oil.

At about the same time that the Russell County discovery drew attention to the area of the Central Kansas uplift, another development was taking place in extreme southwestern Kansas. A well drilled in Seward County directed attention to the area which has

become the important Hugoton gas field. The well was drilled by the Defenders and Traders Gas Company in sec. 3, T. 35 S., R. 34 W., in what is now the Liberal pool. Five years later the discovery well of the Hugoton field proper was drilled in Stevens County. Credit goes to the Independent Oil and Gas Company's No. 1 Crawford well, in sec. 31, T. 33 S., R. 37 W. From that beginning, the Hugoton field has increased to an area of about 2 million acres, covering parts of nine counties—Stevens, Seward, Morton, Stanton, Grant, Haskell, Hamilton, Kearny, and Finney. The field is spoken of as the most important reserve of natural gas that is known anywhere at the present time. Production is nearing 200 billion cubic feet of gas per year (183 billion in 1947).

A summary of the more important western Kansas pool discoveries mentioned chronologically reveals various surges of petroleum activity. Following the Fairport pool discovery in Russell County in 1923, the Welch pool was found in Rice County in 1924, and the Churchill (19)* and Gorham (33) pools in Sumner and Russell Counties in 1926. Three well-known pools were opened in 1927—the Medicine Lodge gas pool (119 billion cubic feet cumulative) of Barber County, the Oxford pool (15.5) of Sumner County, and the Laton pool (3) of Rooks County, which was not extensively drilled until about 1940. In 1928, the first well to find oil in the Arbuckle dolomite, now by far the largest producing oil formation in Kansas, was completed in the North Ellis pool (Shutts) in Ellis County. Two important pools, the Valley Center (21.5) and the Goodrich (4) in Sedgwick County were brought in during the same year.

A half dozen important pools were discovered in western Kansas in 1929, which was a year of easy money, free spending, and broad business expansion until the stock market crash of that year. In McPherson County, the Ritz-Canton (40) and Voshell (27) pools were opened, as were the Raymond (11) in Rice County, the Wellington (6) in Sumner County, and the Greenwich (10.5), the Eastborough (8.5) and the Robbins (3.3) in Sedgwick County. Farther west, the Aldrich pool (1.4) was discovered in Ness County, and the Riga pool, soon abandoned, but revived in 1947, in Trego County. In 1930 two important gas pools, the Burrton (62 billion cubic feet cumulative gas production) in Reno County and the Otis (116 billion cubic feet cumulative gas production) in Rush County

*Figures in parentheses after the pool names are cumulative production of oil to date in millions of barrels.

were opened. The Richardson (8.5) oil pool of Stafford County also was discovered.

Of all the years of petroleum history in Kansas—except perhaps 1914 and 1915 when the Butler County pools were opened—1931 saw the discovery of the greatest number of important oil pools. Those found in western Kansas were the Hall-Gurney (34) of Russell County, the Chase (46) of Rice County, the Silica (77) of Barton County, the Stoltenberg (25) of Ellsworth County, the oil phase of the Burrton (42) of Reno County, the Hollow-Nikkel (20) of Harvey County, and the Cunningham (6) of Pratt County. Cumulative production to date of the above seven pools (omitting numerous other less important pools discovered in the same year) was almost one-quarter of a billion barrels of oil.

The depression year 1932, which saw financial despair in many quarters and little industrial development in the country, was a year in which no important oil pool was discovered in western Kansas. The Wherry pool (10) was discovered in Rice County in 1933 as oil activity increased somewhat from the relative stagnation of the previous year. The following year, 1934, was a little better. Among the half dozen pools of importance discovered during the year were the Geneseo (22) in Rice County, the Graber (9) in McPherson County, the Russell (7) in Russell County, the Lorraine (10) in Ellsworth County, the oil phase of the Otis pool (3) in Rush County, and the Hilger (3) in Reno County. In far western Scott County the smaller Shallow Water pool was discovered.

In 1935, the Bemis-Shutts pool (49) was discovered in Ellis County and the Big Creek pool (10) in Russell County.

The Trapp pool was discovered in Russell County in 1936. For several years it has been the largest producing pool in the State, and it has the second largest total production since discovery, 95 million barrels of oil (the ElDorado pool in eastern Kansas being number one with 195 million barrels to its credit since discovery). Other important pools discovered in 1936 were the Bloomer (27) in Barton County, the Edwards (9) in Rice County, the Walter (3.9) in Ellis County, and the Pawnee Rock (1.7) in Pawnee County.

Five important pools were opened in 1937—the Burnett (28) in Ellis County, the Zenith (23) in Stafford County, the Bornholdt (11) in McPherson County, the Drach pool in Stafford County which has a cumulative of only 2.8 million barrels, but which is now an important producer with a record of more than 540,000 barrels in 1947, and the Kraft-Prusa (31) in Barton County.

During the next 3 years, oil discoveries in western Kansas were of somewhat less importance. In 1938, the Morel pool (5.7) was opened in Graham County, and the Nunn pool, which has produced less than 1 million barrels since discovery but which is regarded as important because of its location, was discovered in Finney County. In that year, two pools which have modest total productions but which are large producers now, 10 years later, were discovered in McPherson County. They are the Lindsborg (4.2) and the Roxbury (2.5). The Ray pool (7) was discovered in Phillips County in 1940, and the Stafford pool (2.3) in Stafford County in the same year.

The use of cumulative production of pools since their discovery to reckon their importance becomes a bit unfair to the younger pools which have not had time to accumulate imposing production records. Therefore, both current annual production and total production since discovery have been used in selecting the most important pools that have been discovered since 1940.

One important gas pool, the Zook, with a cumulative total of 5.7 billion cubic feet, was discovered in Pawnee County in 1941, and in the same year two oil pools, the Barry (2.5) in Rooks County, and the Forest Hill (1.3) in Russell County, were brought in. The last two pools produced approximately 800,000 and 400,000 barrels of oil, respectively, during 1947. The most important 1941 discovery was the Peace Creek (10) in Reno County. The smaller Sun City pool (1) was discovered in Barber County about the same time.

In 1942, several pools were opened; some are substantial producers now. Perhaps the two most important were the Carmi pool (6) in Pratt County and the Skinner North gas pool (13 billion cubic feet cumulative) in Barber County. Next in importance was the Merten pool (2.3) in Barton County with a production of 617,000 barrels of oil during 1947. The Merten pool has been combined with the Albert pool. Lesser pools that are still good producers were the Crowther in McPherson County, the Boyd in Barton County, the Smyres in Rice County, and the Ellis pool in Ellis County.

The outstanding pool discovery of 1943 was the Chitwood (3.7) in Pratt County. It produced more than a million barrels, (1,160,000) of oil during 1947. Other 1943 pools worthy of mention were the Riverview in Ellis County, the Hansen in Phillips County, the Hilger North in Reno County, and the Hunter and Salina pools in Saline County.

Sheridan County in northwestern Kansas supplied the most

important discovery of 1944, the Adell oil pool. Although its cumulative production is less than 1 million barrels, it produced 339,000 barrels of oil during 1947. Two other 1944 pools, the Jenday in McPherson County and the Pleasant in Ellis County, are now producing at a rate of more than 100,000 barrels of oil per year.

Two important pools were discovered in 1945, the Vohs in Rooks County and the Ryan in Rush County. They produced 257,000 and 166,000 barrels of oil, respectively, in 1947.

The history of the petroleum industry in Kansas in the post-war period has been contrary to pattern and expectation. It was commonly supposed that refining capacity—and production for that matter—which had been increased almost to the limit on account of war requirements, would be ample or excessive for peace-time needs, but unforeseen changes have taken place which have embarrassed both producers and refiners. The Marshall Plan for the assistance of Europe has increased requirements for petroleum products for export; a rejuvenated military program, especially in aviation, has added to the domestic requirements for petroleum products; and the urge of the average American to get the family car out to go places after several years of war restrictions has caused gasoline demand to be considerably greater than had been expected. Furthermore, there has been a significant change in the attitude of both industry and the domestic consumer toward fuels. Whereas coal and oil have been the stand-bys for industrial fuel and also for domestic heating in some parts of the country, natural gas is becoming the fuel most greatly desired both by industry and by the home owner. Labor and transportation difficulties and the smoke nuisance have helped to bring about the lessening demand for coal both for industry and for home heating. Natural gas, because it is relatively cheap and also clean and easy to use, is in increasing demand. That demand, supported by the development of such reserves as the Hugoton field, and resulting in the consequent demand for steel pipe of large sizes, 24 inches or more, has the pipe mills of the country loaded with orders into 1951, according to news reports. This demand for pipe for natural gas, crude oil, and product pipe lines (to transport petroleum and its products much more rapidly and cheaply than by rail) has had the effect of hindering oil production by causing a serious scarcity of rods, casing, and other tubular goods.

With the current crude oil production in the United States at about 5.5 million barrels per day, Kansas—the fifth state in point

of rank—is literally drilling and producing as never before. In the first half of 1948 exploration in Kansas was stepping up at a rate about 35 per cent greater than in 1947. Behind this effort at greater production is, as usual, the profit incentive. Kansas oil has an average value now (September, 1948) of about $2.50 per barrel. There were three price advances during 1947. Indications are that there may be a further rise yet this year. Changes in the total value of crude oil and natural gas in Kansas reflect the product of sharply increased output times the greatly enhanced price. Table 12 shows the price change in recent years and the apparent trend.

Table 12.—Production and value of petroleum in Kansas.

	Oil		Gas		
Year	Million bbls.	Million dollars	M. cu. ft.	Million dollars	Total value million dollars
1946	97.2	138.8	164.0	55.8	194.6
1947	103.9	200.1	183.5	62.4	262.5
1948*	110	275	200	68	343

*Estimated

This rather startling increase in the total value of petroleum in Kansas in a 2-year period probably is approximately in line with the corresponding increase in the value of agricultural products of the State in the same period. The total value of oil and gas for 1948, estimated roughly at 343 million dollars, when added to the value of other mineral products of the State, should bring the total of the State's mineral production close to the 400 million dollar mark for 1948.

Distribution of producing areas.—A glance at the index map (Fig. 2) reveals three main petroleum areas: one in southeastern Kansas, one about midway or a little west of the center, and one—the Hugoton gas field—in the southwest corner of the State. These

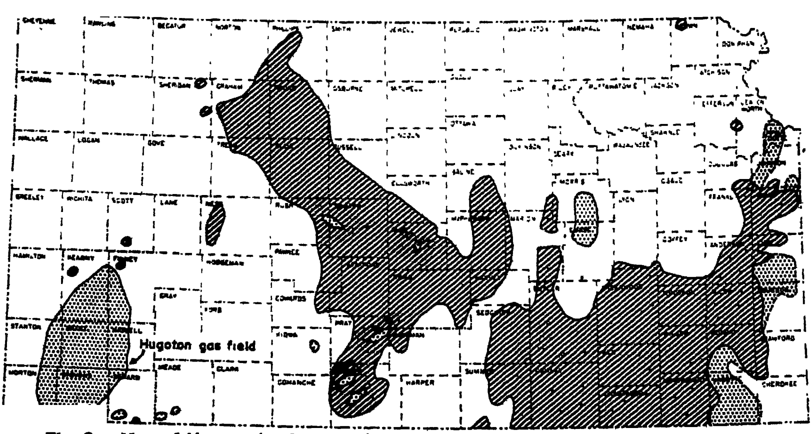

Fig. 2.—Map of Kansas showing petroleum areas. Diagonals, oil; dots, gas.

divisions correspond rather closely to what are commonly called "the old eastern Kansas fields," the "western Kansas" or "Central Kansas uplift area," and the Hugoton field. The eastern half of the easternmost area, including Chautauqua, Montgomery, Labette, Wilson, Neosho, Crawford, Woodson, Allen, Bourbon, Anderson, Linn, Franklin, Miami, Douglas, and Johnson Counties are noted mainly for their water-flooding activities at the present time. It was in these counties that production began in Kansas and flourished around the turn of the century. They are now noted for their shallow "stripper" production. The remaining counties of eastern Kansas have somewhat larger per-well average production from considerably greater depths. Two features, the rather important shoestring sand production of Greenwood County and the more important production of the ElDorado field, are worthy of note.

Production within the area of the Central Kansas uplift, or "western Kansas," has featured the State's oil activity for the last 10 or 15 years. It is in this area that spectacular production has been discovered with such fields as the Trapp, Silica, Kraft-Prusa, and Bemis-Shutts.

Development of the Hugoton gas area was not pushed until pipe line facilities made possible the distribution and sale of substantial amounts of natural gas to distant areas of larger population and to industrial centers.

Geology.—Oil or gas has been found in Kansas at the top of the Pre-Cambrian or basement complex and in at least a dozen stratigraphic subdivisions from there up to the Cretaceous.

Rocks of several ages are included among the sedimentary sequences overlying the Pre-Cambrian in Kansas. Of the six main divisions of these sediments which are recognized (Moore and Jewett, 1942, p. 2), five—excluding the topmost division—contain rock layers that produce oil or gas. In ascending order, these are:

1. The Cambrian-Ordovician rocks, mainly dolomite and limestone. This division includes the Lamotte sandstone, the Arbuckle dolomite, the Simpson formation, and the Viola limestone or dolomite, all of which are well-known oil-producing zones at various points in the State.

2. The Silurian-Devonian rocks, which are mainly dolomite and limestones. The "Hunton lime," an oil-producing unit of some importance, occurs in this division.

3. The Mississippian rocks, mainly limestones, some of which have produced substantial amounts of oil.

Geologic System	Some Subdivisions
Quaternary	Recent— Alluvium (Pleistocene) glacial sediments
Tertiary	(Pliocene) Ogallala
Cretaceous	Pierre shale Niobrara chalk Carlile shale Greenhorn limestone Graneros shale Dakota clays Kiowa shale Cheyenne sandstone
Jurassic ?	
Permian	Stone Corral dolomite Herington limestone (gas) Winfield limestone (gas) Ft. Riley limestone (gas) Wreford limestone (gas)
Pennsylvanian	Tarkio limestone Topeka limestone Oread limestone Lansing-Kansas City sequence (limestones) "Wayside sand" "Peru sand" Ft. Scott limestone "Squirrel sand" "Bartlesville sand" "Burgess sand" Sooy (basal) conglomerate
Mississippian	"Chat" "Mississippi lime" Misener sand
Silurian and Devonian	"Hunton limestone"
Ordovician	Sylvan shale Viola limestone Simpson-St. Peter sandstone Arbuckle dolomite
Cambrian	Lamotte (Reagan) sandstone
Pre-Cambrian	Granite and quartzite

Fig. 3.—Generalized geologic column showing rock units commonly used by drillers and petroleum engineers.

4. The Pennsylvanian - Permian rocks. The lower rocks of this division consist mainly of limestones with some shale, and produce an important amount of oil. The upper, or Permian, part produces 75 per cent of the natural gas of the State but no oil. It is composed principally of red, sandy, and shaly beds which because of their characteristic color are commonly referred to as the "Permian red beds."

5. The Cretaceous rocks, consist mainly of sandstone, shale, and chalky limestone. One small gas pool, the Goodland, near the town of that name in Sherman County comprises the total production of the State from

the Cretaceous to date.

The major rock units and some of the minor but better-known units that are recognized by drillers and oil geologists are indicated in Figure 3.

Oil and gas production in Kansas is definitely related to several broad features of the structural geology. These features consist of wide, shallow basins, separated by low arches or up-warped areas, called uplifts. Two pronounced uplifts, the Central Kansas and the Nemaha, are recognized. The basins are the Forest City of northeastern Kansas, the Cherokee of the southeastern part of the State, the Salina of north-central Kansas, the Sedgwick south of the Salina, and the Dodge City in southwestern Kansas. The relationships among these several major structural features are shown in Figure 4 (Moore and Jewett, 1942, p. 6).

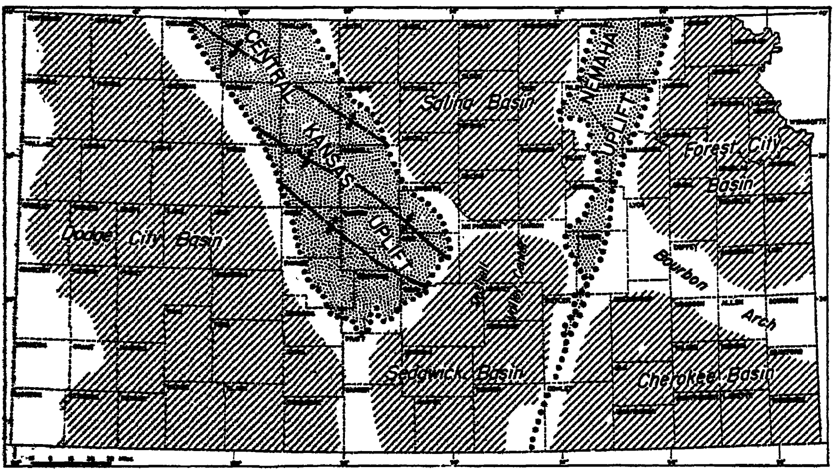

Fig. 4.—Major structural features of Kansas geology (after Moore and Jewett, 1942).

Oil was first discovered in Kansas in the southern part of what is now referred to as the Forest City basin. It was extended southward into the Cherokee, then westward into Butler County where fields located on the southern part of the Nemaha uplift were found. The next important discovery of oil was in Russell County in the early 1920's on what is now recognized as the Central Kansas uplift, and gas was found at almost the same time near Liberal in the southwestern part of the Dodge City basin. This last discovery has since become the Hugoton gas field.

An idealized cross section (Fig. 5) through the sedimentary

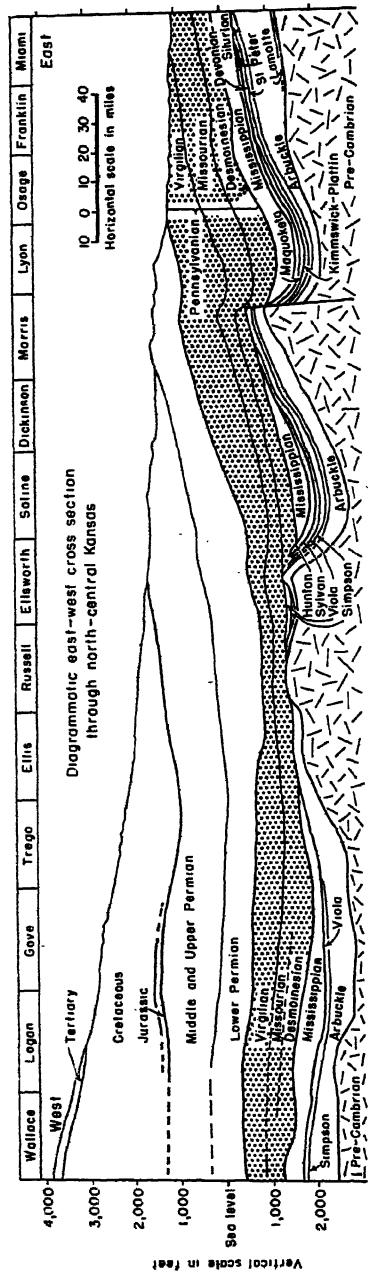

Fig. 5.—Generalized cross section of Kansas rocks (after Jewett, Frye, and Thompson).

rocks of Kansas from west to east clearly shows the lensing in and out of the many formations and sequences, the thickening and thinning of the major divisions of the rocks, the nature of the structural and deformational features, and the contact relations of the unconformable beds.

The largest and most productive oil and gas pools in the State are located favorably with respect to one or the other of the above-named major structural features. Examples of oil pools located on favorable structure or large up-warps are the ElDorado pool (*field* is probably better in this case), the Trapp pool in Barton County, and the Silica pool in Barton and Rice Counties. The two last-mentioned pools are on the Central Kansas uplift. Important gas fields seem to favor the basin areas. Examples are the Hugoton field in the Dodge City basin, the Cunningham and Medicine Lodge fields in the Sedgwick basin, and the formerly important Iola-Chanute-Independence fields in the Cherokee basin of southeast Kansas.

Deposits of oil or gas in Kansas, referred to as pools or fields, are caused by liquid or gaseous hydrocarbons being trapped in porous rocks beneath the surface. Two kinds of traps, structural and depositional, account for Kansas petroleum production. Most structural traps, called "structures," are dome- or ridge-like folds in the rocks, caused by lateral compression. Such structures are called anticlines, domes, or terraces, and they have widths of from a few hundred feet to several miles. The anticlines may have lengths many times their widths. Anticlinal structures not underlain by porous, oil-bearing rocks, are of course, barren, but it is almost axiomatic in Kansas that — other conditions being favorable — good local structures, such as anticlines, have offered the most attractive conditions for the accumulation of oil.

Depositional traps, common in Kansas, result mainly from a condition of porosity wherein a porous area of a given oil or gas "sand" grades in all lateral directions to a less porous or impervious condition. Porosity in an oil-bearing rock to allow migration and accumulation of oil or gas—and their controlled escape when tapped by drill holes—is a most essential condition to the formation of oil pools. It is next in importance to the presence of liquid and gaseous hydrocarbons somewhere in the same or in a nearby sequence of sedimentary rocks. The Cunningham gas pool in Pratt and Kingman Counties is an example of a depositional trap. The Lansing-Kansas City formations of Middle Pennsylvanian age have been hosts to

notable accumulations of oil and gas in areas where the rocks are porous but without attractive structure.

The Hugoton gas field, which with its extensions into Oklahoma and the Texas Panhandle is now regarded as the largest known gas reserve in the world, is essentially a stratigraphic trap. The relatively porous, dolomitic marine strata which occur in the main part of the field and on the down-dip or east side, grade laterally to fine-grained, rather dense, less porous continental strata up the dip to the west (Moore and Jewett, 1942, p. 15). Thus a trap has been formed.

Another and somewhat different type of depositional or stratigraphic trap is represented by the so-called "shoestring" sands of Butler, Greenwood, and other eastern Kansas counties. Original deposits consisting of channel-fillings of narrow offshore bars or spits of pervious sediments which grade laterally into impervious shales or other denser rocks, have permitted important accumulations of oil in the form of long, narrow lenses or "shoestrings."

It seems unlikely that any new, major structural features will be revealed, or that any new Kansas oil pools will be discovered to challenge the ElDorado or the Trapp pools in productivity. However, it is almost a certainty that many new pools will be discovered, and that exploration and production methods will be greatly improved to offset in part the decline in productivity of many of the fields in the State.

*The fields.**—No oil or gas field in the State or as far as known in the United States ranks in area with that of the Hugoton gas field in Kansas, Oklahoma, and the Texas Panhandle. At present its area in Kansas is approximately 2 million acres. Around 1900, there were very large areas, such as the Iola-Humboldt-Chanute field, that produced both oil and gas, but such areas never approached either the area or the current production of the Hugoton.

The oil pools of Kansas range in size from a few acres, representing the drawing area of a single well, to nearly 40,000 acres or about 60 sections, which is the present size of the Trapp pool. In the so-called western Kansas counties, that is, west of Butler County, rather complete statistics are available, but for the eastern counties

*The terms "field" and "pool" have come to be used almost synonymously which perhaps is unfortunate. "Pool" has been described as meaning a producing unit virtually without barren spots; whereas "field" is used more loosely to include the general area of present or past production. It may include several producing units. For example, the Paola-Rantoul field in Franklin and Miami Counties covers a very large area most of which is idle or unproductive at the present time, although it contains a number of small producing areas, mainly secondary oil recovery operations.

where production is more "hit or miss," figures either are not available or are merely approximations. A true figure for the total producing acreage of Kansas oil and gas pools cannot therefore be given. For oil pools, a figure of 575,000 acres or 900 square miles, about 1.1 per cent of the area of the State, would probably be fairly close. The present gas-producing areas, including the area of the Hugoton field, probably totals about 2,225,500 acres or about 4.3 per cent of the area of the State.

The most important oil field, or the greatest field, the State has had is the ElDorado. In addition to its record of having established Kansas as a foremost oil-producing state, it has a cumulative record (nearly 200 million barrels of oil) of production more than twice that of any other pool in the State. Discovered in 1915, it is now more than 30 years old, is still going strong, and must be respected as the patriarch of all Kansas fields. Figure 6 shows in millions of barrels the cumulative oil production of the ten ranking pools in Kansas.

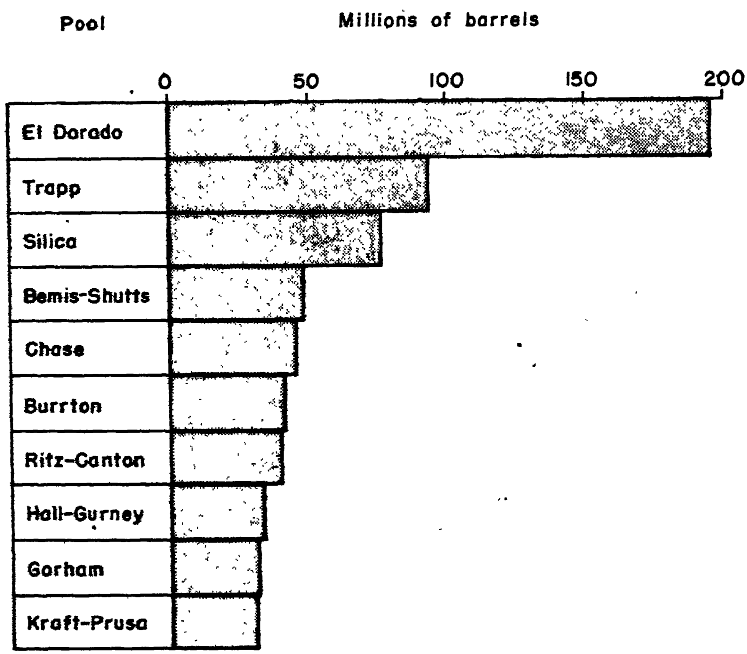

Fig. 6.—Leading Kansas oil pools in order of cumulative production.

Far surpassing all other fields in recent years is the Trapp oil pool in Russell County. Its production of more than 11 million barrels of oil in 1947 rates it as one of the important oil fields of the country. Figure 7 shows the 10 most important Kansas oil fields in point of current production. After the Trapp, the Kraft-Prusa, Bemis-Shutts, and Silica pools follow closely, each with current yearly productions running well into the millions of barrels.

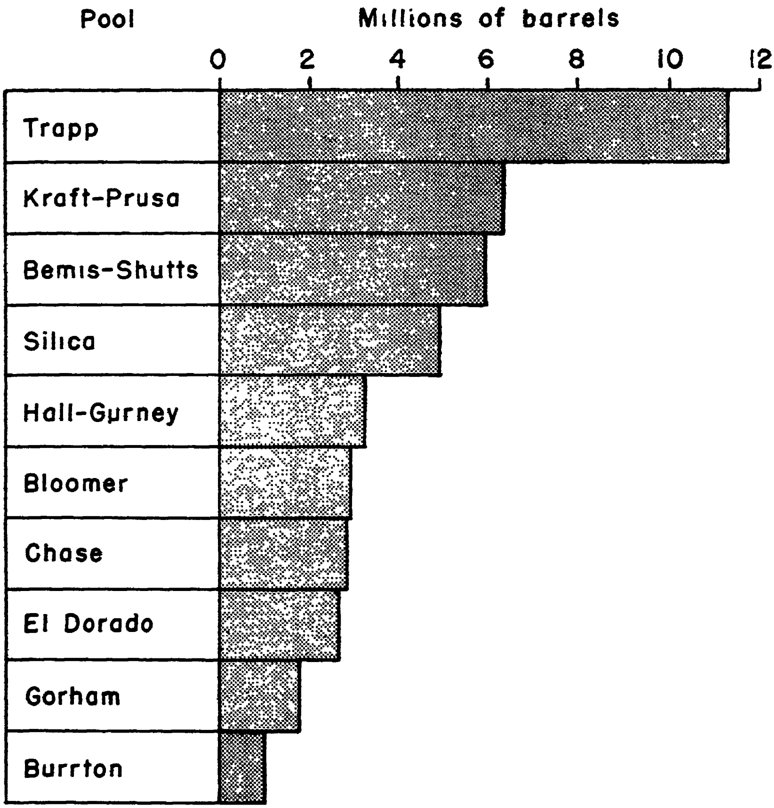

Fig. 7.—Kansas oil pools in order of production during 1947.

It would perhaps have been desirable to include in this paper a table showing each of the 621 oil pools producing in 1947 in the State and statistics for each, and the same coverage for the gas pools, but (although most of the data have been compiled) it would have consumed pages of space without adding pointedly to the overall picture of the oil industry which this paper seeks to convey. The reader is referred to the annual reports of the State Geological Survey of Kansas entitled *Exploration for Oil and Gas in Western*

Kansas (Ver Wiebe, 1938-1947), and to a corresponding report, Bulletin 57 of the Survey series, entitled *Oil and Gas in Eastern Kansas* (Jewett and Abernathy, 1945). These reports, and others on the same subject published by the Survey, give data in great detail on the pools, their size, production, number of wells, depths to principal producing zones, and also much geological and exploratory information.

However, for the purposes of this paper it has seemed better to reduce the information to a county basis. This has been done to the limit of available information in Table 13. Footnotes explain seeming anomalies in the figures or information. One discrepancy should be mentioned. That is in regard to the number of wells drilled in Kansas in 1947. The figures given for all counties west of and including Butler, are believed to be quite accurate, but for the remainder of the counties to the east the figures are believed to represent only a portion of the number actually drilled. The reason for this is that in the southeastern counties, where drilling is relatively shallow and where much of the activity is carried on by smaller companies and individuals, records are more difficult to obtain, and there is no such general scheme of supplying drilling data to a central clearinghouse as is done in the western counties. The State Geological Survey is making an effort to collect more accurate and complete data on petroleum operations in eastern Kansas.

Table 13.—Petroleum data for producing counties in Kansas, 1947.

County	No. of pools: Oil	No. of pools: Gas	Acres: Oil	Acres: Gas	Producing wellsA: Oil	Producing wellsA: Gas	1947 Production: Oil	1947 Production: Gas	Wells Drilled 1947: Oil	Wells Drilled 1947: Gas	Wells Drilled 1947: Dry	Wells Drilled 1947: SWDK	Wells Drilled 1947: Total	Secondary Recovery Operations	Principal Producing Zone	Approx. Depth
Allen	7	C	B	B	317	C	284,240	D	.. ..	......	......	....	.. ..N	10	"Bartlesville"	600- 800
Anderson	6	C	B	B	296	C	325,288	D	.. ..	......	......	....	.. ..N	13	"Bartlesville" "Squirrel"	500 800
Barber	6	8	3,130	9,320	110	63	1,185,650	18,720,177	38	3	23	0	64	0	"Chat"	4,400
Barton	52	3	65,300	2,650	1,937	12	17,540,101	5,464,413	222	6	112	2	342	1	Arbuckle	3,300
Bourbon	2	C	B	B	89	C	31,660	D	.. ..	......	1	....	1N	0	"Bartlesville"	500- 700
Brown	1	0	B	0	1	0	9,630	0	1	......	......	....	1N	0	"Hunton"	2,300
Butler	42	C	B	B	2,739	C	5,611,484	D	181	1	87	3	272	14	Arbuckle	2,500
Chase	M	C	B	B	C	C	35,137	D	.. ..	......	......	....	.. ..N	0	"Bartlesville"	2,700
Chautauqua	14	C	B	B	1,347	C	830,535	D	2	......	......	....	2N	11	"Peru"	1,200
Coffey	1	C	B	B	19	C	12,970	D	1	......	......	....	1N	0	"Peru"	1,500
Cowley	47	C	B	B	695	C	2,647,860	245,114	46	1	58	0	105N	5	"Bartlesville"G	1,600
Crawford	4	..	B	B	27	C	60,792	D	.. ..	......	......	....	.. ..N	2	"Bartlesville"	300
Dickinson	2	C	B	B	37	C	32,190	D	20	0	14	0	34N	0	"Chat"	2,300
Douglas	1	..	B	..	15	..	5,110	....	.. ..	......	......	....	.. ..N	0	"Squirrel"	600- 700
Edwards	0	1	0	640	0	2	0	921,521	0	0	1	0	1	0	K.C.-Lansing	3,800
Elk	16	C	B	B	277	C	239,975	D	1	......	1	....	~2N	3	"Wayside"G	700
Ellis	37	0	34,160	0	1,031	0	11,696,661	0	124	0	67	6	197	0	Arbuckle	3,600
Ellsworth	6	0	25,250	0	378	0	4,702,823	0	35	0	16	1	52	0	Arbuckle	3,300
Finney	1	F	600	P	14	P	192,424	P	3	36	1	0	40	0	Mississippian	4,700
Franklin	6	C	B	B	520	C	188,185	D	.. ..	......	1	....	1N	3	"Squirrel"	500
Graham	7	0	4,660	0	95	0	1,655,876	0	13	0	27	1	41	0	Arbuckle	3,700
Grant	0	F	0	P	0	P	0	P	0	59	0	0	59	0	P	P
Greenwood	34	C	B	B	2,235	C	4,109,418	D	44	1	29	11	85N	33	"Bartlesville"	1,900
Hamilton	0	F	0	P	0	P	0	P	0	1	0	0	1	0	P	P
Harvey	5	1	4,080	800	76	3	232,056	266,695	4	0	2	0	6	4	"Chat"	3,100
Haskell	0	F	0	P	0	P	0	P	0	19	0	0	19	0	P	P
Hugoton Field	0	1	0	1,800,960	0	1,256E	0	140,839,734	.. ..	......	......	....	.. ..	0	Permian	2,500
Jefferson	2	..	B	..	25	..	109,702	....	.. ..	......	......	....	.. ..N	0	Basal Penn.	1,900
Johnson	0	C	0	B	0	C	0	150,000	.. ..	......	......	....	.. ..N	0	"Squirrel"	700

Table 13—Continued

County	No. of pools: Oil	No. of pools: Gas	Acres: Oil	Acres: Gas	Producing wellsA: Oil	Producing wellsA: Gas	1947 Production: Oil	1947 Production: Gas	Wells Drilled 1947: Oil	Wells Drilled 1947: Gas	Wells Drilled 1947: Dry	Wells Drilled 1947: SWDK	Wells Drilled 1947: Total	Secondary Recovery Operations	Principal Producing Zone	Approx. Depth
Kearny	1	F	..	P	3	P	40,374	P	0	88	1	0	89	0	P	P
Kingman	1	..	595	J	3	C	166,258	430,799	2	0	8	0	10	1	K.C.-Lansing	3,400
Labette	1	C	B	B	15	C	6,958	D	......	......	......	....	......N	0	"Bartlesville"	500
Leavenworth	2	C	B	B	8	C	13,995	D	......	......	2	....	2N	0	"Squirrel"	750
Linn	4	C	B	B	246	C	73,163	D	......	......	......	....	......N	3	"Squirrel"H	400
Lyon	3	..	B	..	112	..	120,163	....	4	......	4	....	8N	1	"Bartlesville"	1,900
Marion	11	C	B	B	222	C	506,442	D	10	......	21	1	32N	1	"Chat"	2,300
McPherson	22	2	41,200	1,660	928	21	4,821,421	619,857	51	2	35	0	88	13	"Chat"	2,600-3,000
Meade	0	2	0	320	0	2	0	idle	0	1	1	0	2	0	Mississippian	5,800
Miami	11	C	B	B	937	C	290,806	D	......	......	......	....	......N	9	"Squirrel"H	450
Montgomery	9	C	B	B	1,704	C	1,377,605	D	......	......	......	....	......N	25	"Bartlesville"	1,000
Morris	1	..	B	..	1	..	390	....	......	......	2	....	2N	0	"Chat"	2,400
Morton	0	F	0	P	0	P	0	P	0	14	1	0	15	0	P	P
Neosho	6	C	B	B	268	C	435,158	D	2	......	......	13	15N	3	"Bartlesville"	750
Ness	4	0	6,520	0	29	0	239,854	0	1	0	2	0	3	0	Warsaw	4,500
Norton	2	0	120	0	3	0	15,163	0	1	0	3	0	4	0	Arbuckle	3,600
Pawnee	8	4	3,980	800	69	5	404,626	2,839,573	25	5	23	0	53	0	Arbuckle	3,800
Phillips	6	0	7,100	0	171	0	1,894,238	0	21	0	11	1	33	0	Arbuckle K.C.-Lansing	3,500 3,300
Pratt	12	0	11,630	14,000	357	40	2,911,933	2,299,902	6	0	14	0	20	1	Viola Arbuckle	4,100 4,300
Reno	8	1	22,440	5,800	494	315	2,622,755	3,400,629	4	0	8	0	12	2	"Chat"	3,200
Rice	30	3	56,700	3,180	1,039	13	11,528,761	474,665	103	6	49	5	163	3	Arbuckle	3,200
Rooks	29	0	12,990	0	305	0	2,506,085	0	93	0	75	0	168	0	K.C.-Lansing	3,200
Rush	6	1	3,460	7,500	78	66	496,428	2,237,925	14	1	19	0	34	0	Reagan	3,500
Russell	31	0	73,100	0	2,644	0	15,153,795	0	112	1	40	8	161	4	Arbuckle	3,200
Saline	5	0	2,150	0	52	0	336,161	0	13	0	10	0	23	0	"Chat"	2,700
Scott	1	0	500	0	10	0	79,892	0	......	......	......	....	......	0	Mississippian	4,700
Sedgwick	13	1	5,650	1,840	211	1	629,619	R	7	1	15	1	24	3	Viola	3,300
Seward	0	2Q	160Q	460Q	1	8Q	5,905Q	1,049,363L	1	19	0	0	20	0	Permian (gas) Pennsylvanian (oil)	2,500 6,200

Table 13—Continued

County	No. of pools: Oil	No. of pools: Gas	Acres: Oil	Acres: Gas	Producing wells[A]: Oil	Producing wells[A]: Gas	1947 Production: Oil	1947 Production: Gas	Wells Drilled 1947: Oil	Wells Drilled 1947: Gas	Wells Drilled 1947: Dry	Wells Drilled 1947: SWD[K]	Wells Drilled 1947: Total	Secondary Recovery Operations	Principal Producing Zone	Approx. Depth
Sheridan	3	0	1,340	0	43	0	371,187	0	13	0	4	0	17	0	K.C.-Lansing	3,800
Stafford	48	2	29,110	1,960	765	7	5,340,888	1,154,593	34	2	48	0	84	5	Viola Arbuckle	3,600 3,800
Stanton	0	F	0	P	0	P	0	P	0	52	0	0	52	0	P	P
Stevens	0	F	0	P	0	P	0	P	0	94	0	0	94	0	P	P
Sumner	18	0	9,700	3,640	303	14	1,171,718	0	39	0	19	0	58	3	"Stalnaker" "Chat"	1,900 3,600
Trego	5	0	1,010	0	14	0	87,699	0	5	0	12	0	17	0	K.C.-Lansing	3,600
Wilson	8	C	B	B	188	C	77,281	D	----	----	1	----	1N	1	"Bartlesville"	850
Woodson	13	C	B	B	412	C	404,026	D	9	3	21	----	33N	1	Mississippian[I]	1,200
Misc. Eastern Kansas Gas Production est.	----	----	----	----	----	----	----	2,412,306	----	----	----	----	----	----		
Totals	621	32	426,635	1,855,530	23,915	1,828	105,870,514	183,527,266	1,305	417	907	53	2,682	178	----	----

A In western Kansas counties the number of producing wells comes from official sources and is presumed to be accurate. However, in counties east of Butler the figures for producing wells were obtained from various sources and are probably minimum figures. In fact, in most cases the number is known to be larger than as shown.

B Figures are not available at present on the acreage of oil and gas production in eastern Kansas counties.

C Data not available.

D There is some gas production for this county, included under miscellaneous eastern Kansas, but the amount is not segregated.

E This is the total number of Hugoton wells. Some of them are not connected to pipe lines so the total number of producers is uncertain.

F Gas production within the nine counties that comprise the Hugoton gas field is not segregated as to counties — see under "Hugoton gas field" in this table.

G Also several other Pennsylvanian sands and older rocks.

H Also several other Pennsylvanian sands.

I Also production from Pennsylvanian sands.

J Included in acreage credited to Pratt County.

K SWD stands for salt water disposal.

L This amount of gas was produced from the Liberal Southeast field and is in addition to the amount of Hugoton gas produced within this county.

M The producing pools in Chase County are extensions from Lyon and Greenwood Counties where they are counted.

N In Brown and other eastern Kansas counties, figures for 1947 well completions have been given where known. It is practically certain that wells have been drilled in each county and not recorded.

P Included in figures for Hugoton gas field.

Q These figures apply to the Liberal or Liberal Southeast fields or both and not to the area of the Hugoton gas field which is covered elsewhere.

R There are two gas pools in Sedgwick County — the Derby, not a producing pool but used for the storage of gas, and the Bartholomew, a 1946 discovery from which production has not yet been recorded.

Production.—The production of oil in Kansas doubtless started many years before any official record was kept. The oil produced near Paola and treated there in the small refinery built in the middle 1880's evidently did not get into the record, because the first production given for Kansas in the official record (U.S. Geol. Survey, 1901) was 500 barrels in 1889. Kansas oil production by decades is given in Table 14.

Table 14.—Kansas oil production by decades.

Year	Production, bbls.	Value
1890	1,200	$ 2,500 Est.
1900	74,714	69,142
1910	1,128,668	444,763
1920	39,005,000	133,469,000
1930	41,638,000	54,880,000
1940	66,139,000	68,700,000
1947	103,916,169	200,080,434

Figure 8 shows oil production and value in Kansas the outstanding features of which are the surges of production and value just before 1920, and then during and after the recent war years. In

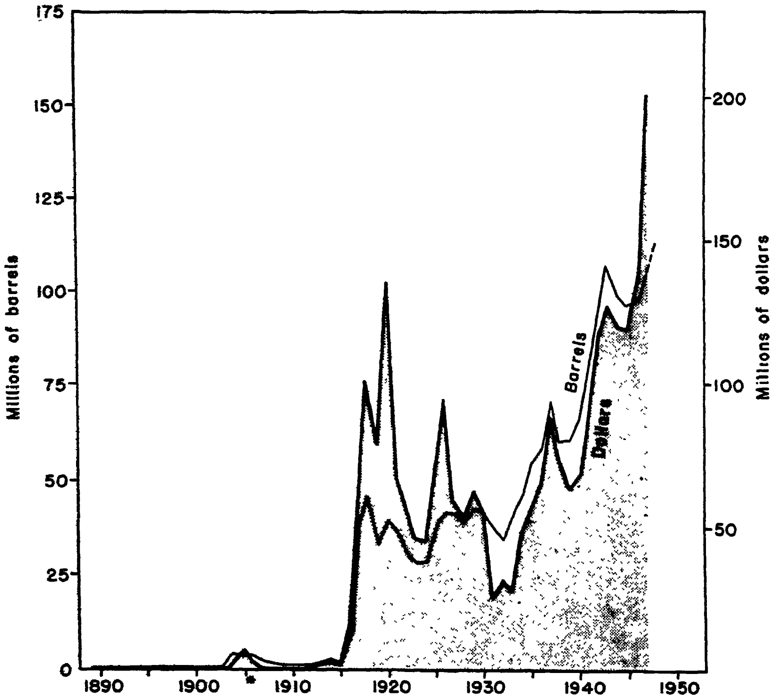

Fig. 8.—Annual production and value of crude oil in Kansas.

the former period, production jumped from a nominal figure in 1915 to 45 million barrels in 1918. That total was not exceeded until

16 years later, in 1934, when Kansas, coming out of the depression, found herself on the march toward the greatly stepped-up production during the war years. Even greater output seems to lie ahead.

Gas production in Kansas (Fig. 9) had its first great surge between 1900 and 1910, when all the production was in the southeastern part of the State, resulting in the amazing industrial expansion which has not since been equaled in that area. Beginning in the early 1930's when the effect of the Hugoton field began to be felt, gas production has increased in Kansas almost every year and at a rapid rate. In 1948, the production in the State will probably reach 200

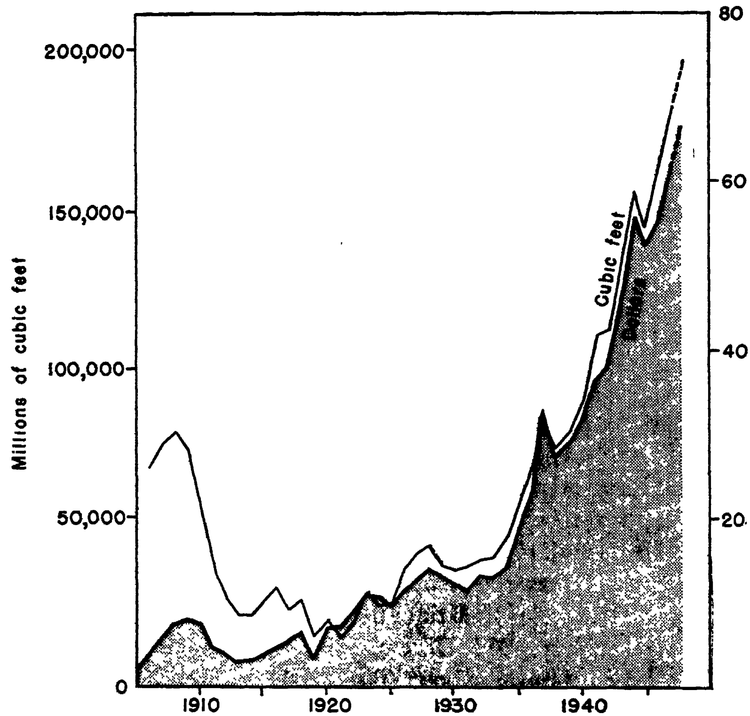

Fig. 9.—Annual production and value of natural gas in Kansas.

billion cubic feet. Natural gas has come into strong demand by industry only in recent years. In many areas it is making deep inroads into the demand for bituminous coal as industrial fuel. The uses of natural gas in Kansas are shown in Table 15.

From Table 15 it is plain that Kansas is producing just about the quantity of natural gas that she uses; the quantity exported is about equal to the amount imported. The Hugoton field produced

Table 15.—Summary of Kansas natural gas production and use, 1947.
(Figures Supplied by *Kansas Corporation Commission*)

Item	During 1947 M. cu. ft.	Cumulative to date M cu. ft.
Gas produced in Kansas—1947	183,527,266	818,254,743
Imported from outside of State	100,700,000	
Total to account for	284,227,266	
Gas used in Kansas during 1947		
Domestic	39,383,000	
Industrial	100,384,000	
Carbon black	21,700,000	
Miscellaneous and losses	17,090,915	
Exported from State	105,669,351	
Total	284,227,266	

roughly 75 per cent of the total production of the State in 1947. The Hugoton gas production is not segregated as to counties, but the following table (Table 16) showing the number of wells drilled in the nine counties covered by or reaching into the field, gives a fair idea of where most of the production and most of the recent activity lie.

Table 16.—Gas wells drilled in the Hugoton field.

County	Total to date	During 1947
Finney	63	36
Grant	269	59
Hamilton	2	1
Haskell	125	19
Kearny	153	88
Morton	59	14
Seward	26	19
Stanton	93	52
Stevens	466	94
Total	1,256	382

Because of the higher prices paid for crude oil since the end of the war, and because of the greater demand for oil and its products, drilling activity in the State has been stepped up markedly. This has been difficult because of the scarcity of steel, machinery, and especially tubular goods including casing, rods, and line pipe. The price of Kansas crude of 36 to 36.9 gravity was $1.17 per barrel on April 1, 1946. Since that time the price has been raised to $2.57, the last raise taking place December 6, 1947. One of the major companies raised its price about 40 cents per barrel to almost $3.00 in September, 1948, but as this is written, the raise has not been matched by the other major companies.

Drilling.—Figure 10 shows the record of wells drilled in Kansas since 1905. Previous to that time, the number drilled each year was only a few dozen up to a few hundred, judging by local records kept by newspapers in southeastern Kansas. The peak in total number of wells drilled about 1905 is referable to the surge of both oil and gas activity during those years in southeastern Kansas. Drilling in Allen, Anderson, and Neosho Counties where activities centered

was relatively shallow, usually under 1,000 feet, so the total footage represented is not so great.

The greatest surge of drilling activity that the State has ever known was between 1915 and 1920 during the development of the important Butler County fields. Drilling then was at modest depths compared to present day standards—2,500 to 3,000 feet. That was in the days of cable tools; rotary drills and rock bits were just coming into use. During the 1920's and early 1930's, drilling

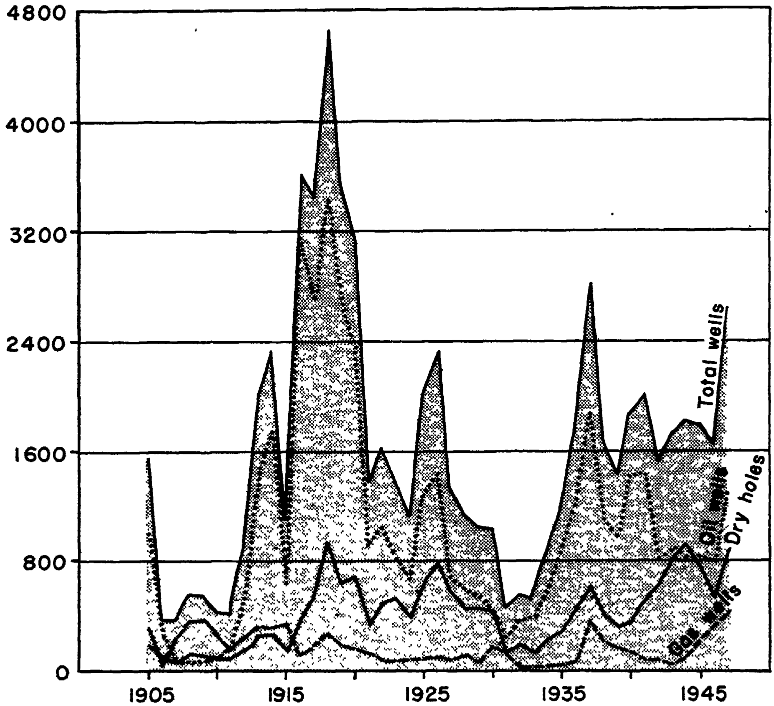

Fig. 10.—Oil wells, gas wells, and dry holes drilled in Kansas.

languished somewhat for various reasons, but since the middle 1930's, drilling has been rather definitely on the increase. This is not apparent from the graph (Fig. 10), mainly because, as pointed out above, the record of wells drilled in eastern Kansas has not been available. It is not unlikely that for the year 1945, for example, the total number of wells drilled in the State was nearer 3,000 than 1,700.

A check of producing wells in Kansas at the beginning of 1948 showed 23,885 oil wells and 3,084 gas wells making a total of 26,969. It is our opinion that if a physical count could be made, it would show probably at least 2,000 more wells of the stripper class that

actually are producing a little oil in the southeastern Kansas counties. This would make a total of about 29,000 producing wells in the State.

Of special significance is the relation between the number of dry holes and the total number of wells drilled in any year. From 1905 to 1940, the ratio of dry holes to total wells drilled would run about 1 to 3 or 1 to 5; but since 1940 the percentage of dry holes has been much higher. For the last 4 years in western Kansas counties, the following percentages of total wells have been dry holes:

	Per cent dry
1944	49.4
1945	39.6
1946	31.8
1947	34.6

The trend toward higher percentages of dry holes is a somewhat disturbing element to the entire industry. It does not suggest any lack of care in scrutinizing geological conditions, or lack of effort by the technical departments of the oil companies. Actually, the major companies and some of the public agencies of the country have gone to great length to devising techniques to reduce dry hole percentages. The trend seems to arise from the increasing scarcity of new pools, to the necessity of drilling to greater depths—making geological prognostication more uncertain, and to the tendency of most operators to take greater chances in drilling wells because of the current demand and price for oil. The cost of exploration and development of new fields has increased substantially in recent years on account of scarcity and cost of labor and materials, and also because of this greater percentage of dry holes.

Pipe lines.—Facilities for conveying and distributing crude oil, natural gas, and petroleum products are planned to meet the requirements of normal times, or at best to meet estimated needs for but a limited future period. So when emergencies develop, such as in war times, facilities of all kinds are inadequate. Through the years, long trains of tank cars have been familiar sights moving across Kansas prairies. However, it is cheaper to move oil and products to market or to refineries through pipe lines than by rail (Fig. 11). So the present trend is to move increasing amounts of petroleum and its products by pipe line—and by motor tank truck.

The necessity of shipping considerable amounts of petroleum products long distances by rail during the last war, only increased the generally severe transportation condition in the country.

Now, Kansas has a network of pipe lines of various kinds criss-

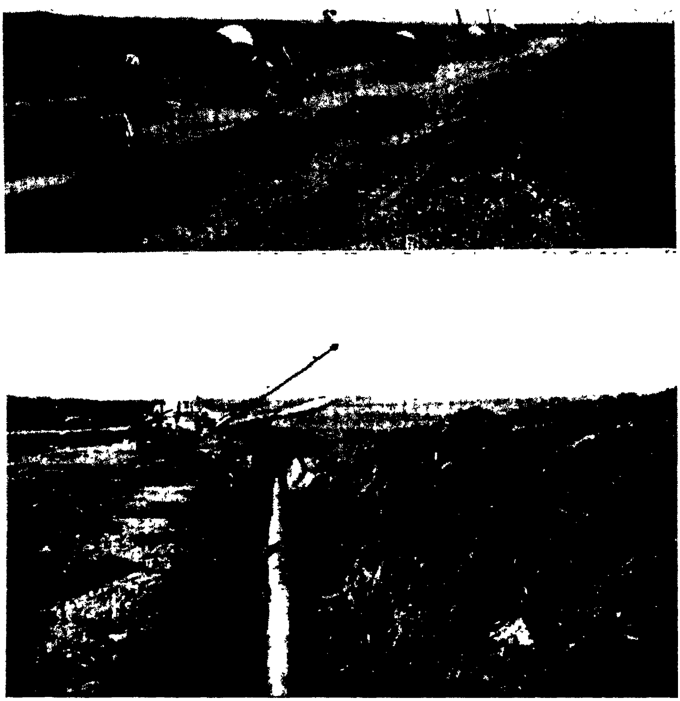

Fig. 11.—Kansas pipe line installation. A. Dropping line into trench. B. Back filling.

crossing the State in all directions, connecting pools with refineries, and gas fields with consuming centers. Since the end of the war in 1945, pipe lines have been built—especially natural gas lines—as rapidly as pipe could be obtained from the steel mills.

One development noted from the present trend toward greater use of pipe lines for conveying oil and its products is the probable relocation of some refining centers with consequent elimination of

some of the smaller units in outlying districts.

Refining.—The history and growth of the petroleum industry in Kansas are closely related to the history and progress of oil refining. Following 1859, when (according to census reports) there were 78 "coal oil" and kerosene plants in the United States, there was no change of note in the refining method for almost 60 years. Straight distillation by application of heat was used. Due to the gradual shift in demand from kerosene to gasoline which began in

Fig. 11C.—Welding on breather pipe.

the late 1890's, oil refineries became much more complex operations, and decidedly more efficient.

Dr. W. M. Burton was the father of the cracking principle in refining, developed for the Standard Oil Company of Indiana in 1913. The cracking principle, with the important catalytic improvement added, is still the dominant refining method used in the industry. The name of Eugene Houdry ranks with that of Burton

because of his contribution in the catalytic process.

Present day plants in the United States, including some of the very old ones, that treat crude oil or natural gas for the manufacture of petroleum products may be divided very roughly into:

1. Distillation plants.
   Method consists essentially of applying heat to the still being charged with crude oil, and of taking off the various fractions that separate naturally in the order of their temperatures of volatilization. Process follows physical laws.
2. Cracking plants. Includes catalytic cracking.
   Method consists essentially of applying both heat and pressure to crude oil which in effect "cracks" the molecule resulting in formation of the desired stable products. Method is a chemical process.
   Use of catalysts in the stills speeds up the process and makes possible formation of stable products of higher octane rating, such as aviation gasolines.
3. Polymerization plants.
   The process is almost the reverse of cracking in that molecules of lighter gaseous hydrocarbons are put together in a manner to create a stable gasoline product.
4. Hydrogenation plants.
   The process, originally developed in Germany and applying mainly to heavy hydrocarbons — coal, asphalt or refinery residues, consists essentially of placing the stock substance under both heat and great pressure in the presence of catalysts and free hydrogen. Gasoline and other less desired products are formed.
5. Natural gasoline and LPG (liquefied petroleum gas) plants.
   Commonly, natural gasoline plants are located in gas fields to recover (by a process of absorption or of compression, or by some combination of the two) natural or casinghead gasoline from the natural gas before the latter, as a dry gas, goes to the consumer.

   LPG plants produce principally propane and butane, the two commonest bottled gases. These formerly consisted mainly of waste gases from natural gasoline plants. Polymerization plants now operate on refinery gases or on propane and butane for production of gasolines.

The so-called recycling plants commonly treat natural gas to recover the gasoline content, then return the gas to the underground reservoir or formation from which it came.

6. Combination plants.

   For economic reasons most present day plants employ combinations of two or more of the above processes.

In Kansas there are 18 crude oil refineries (Table 17) and 13 natural gasoline and LPG plants. They make the usual list of refinery products including high octane and regular gasolines, and lubricating oils.

Table 17.—Kansas oil refineries, 1948.

Name of Company	Location of Refinery	Crude capacity, bbls.	Daily cracking capacity, bbls.
Bareco Oil Co.	Wichita	7,500	3,250
Bay Petroleum Corp.	McPherson	7,000	3,900
Chanute Ref. Co.	Chanute	1,000	1,000
Cooperative Refinery Assoc.	Coffeyville	14,000	5,200
Cooperative Refinery Assoc.	Phillipsburg	4,000	2,200
Derby Oil Co.	Wichita	10,000	4,000
ElDorado Ref. Co.	ElDorado	8,000	4,000
Kanotex Ref. Co.	Arkansas City	9,000	4,500
M.F.A. Oil Co.	Chanute	1,800	1,000
National Coop. Ref. Assoc.	McPherson	18,000	7,000
Phillips Petroleum Co.	Kansas City	36,000	13,000
Socony-Vacuum Oil Co.	Augusta	27,500	7,000
Shallow Water Ref. Co.	Shallow Water	2,500	575
Sinclair Ref. Co.	Coffeyville	15,000	7,000
Sinclair Ref. Co.	Kansas City	10,500	7,000
Skelly Oil Co.	ElDorado	25,000	12,000
Standard Oil Co. (Ind.)	Neodesha	7,700	2,640
Vickers Petroleum Co.	Potwin	6,000	3,250
Total		210,500	88,515

The capacity of the 13 natural gasoline and LPG plants in Kansas (Table 18) is 419,100 gallons, or about 10,000 barrels per day.

Table 18.—Kansas natural gasoline and LPG plants.
(*Oil and Gas Journal*, 1948a, p. 136)

Company and location	Approx. capacity gallons per day
Barnsdall Oil Company	
Rainbow Bend, Cowley County	5,000*
Cities Service Company	
Main Line, Sedgwick County	104,000*
Main Line, Cowley County	30,000*
Burrton, Reno County	30,000*
Continental Oil Company, No. 9, Cowley County	25,000
Edwards Gasoline Company, Zenith, Stafford County	2,000
Flynn Oil Company, Otis, Rush County	8,000*
Kansas Power and Light Company	
Medicine Lodge, Barber County	15,000
McPherson, McPherson County	15,000
Northern Natural Gas Company, Sublette, Haskell County	55,000
Panhandle Eastern Pipe Line Company, Arkalon, Seward County	71,700*
Skelly Oil Company, Cunningham, Kingman County	50,000*
Texas Company, Bearden, Cowley County	8,400*
Total	419,100

*Liquid production including liquefied petroleum gases.

Secondary Oil Recovery.—Oil production in the common manner, namely, by drilling wells into producing zones and collecting the natural flow in pipe lines, or by pumping out the oil when necessary, is called primary production. All oil wells cease flowing naturally in time (many never flow when drilled in and must be put on the pump). Inevitably, there comes a time when a well or group of wells forming a pool declines in production to the point where pumping no longer pays a satisfactory profit. This marks the end of the well's or pool's life of primary production. The operators then either abandon the operation or resort to some device to reactivate the well or pool to increase production.

Primary oil production as practiced in the industry up to this time recovers only from 20 to 50 per cent of the total oil present in the producing zone. About 33 per cent is given as a common average for primary oil recovery. The remainder stays in the oil "sand" as films adhering to the "sand" grains, or as microscopic droplets caught in the interstices between the grains or in tiny cavities in the rock. The percentage of oil remaining in a producing zone can be determined satisfactorily by taking a core from the zone and testing it in the laboratory to see how much oil is actually present.

Secondary oil recovery operations employ various devices or schemes to recover more of the oil that remains in the "sand" after primary methods are abandoned or found not sufficiently remunerative.

The decline in production of oil pools is commonly explained by the gradual dissipation of the pressure of natural gas which drives the oil out of the "sands" and up to the surface when wells tap the oil-bearing zone. The pumping of natural gas from some other source down into the oil sand, called "re-pressuring," is sometimes resorted to. When natural gas is not available for re-pressuring, air may be pumped down into the sand. This is called "air-drive." The introduction of air may cause serious corrosion of pipe lines and pumps where salt water has invaded the oil sand and has to be pumped with the oil. Largely because of this, one operator, Stanolind Oil and Gas Company, has installed an experimental re-pressuring operation in Barton County, Kansas, using nitrogen, a relatively inert gas, as a re-pressuring medium. The results of that operation have not yet been announced.

The most popular and widely-used method of secondary oil recovery in Kansas is so-called water-flooding (Fig. 12). It consists

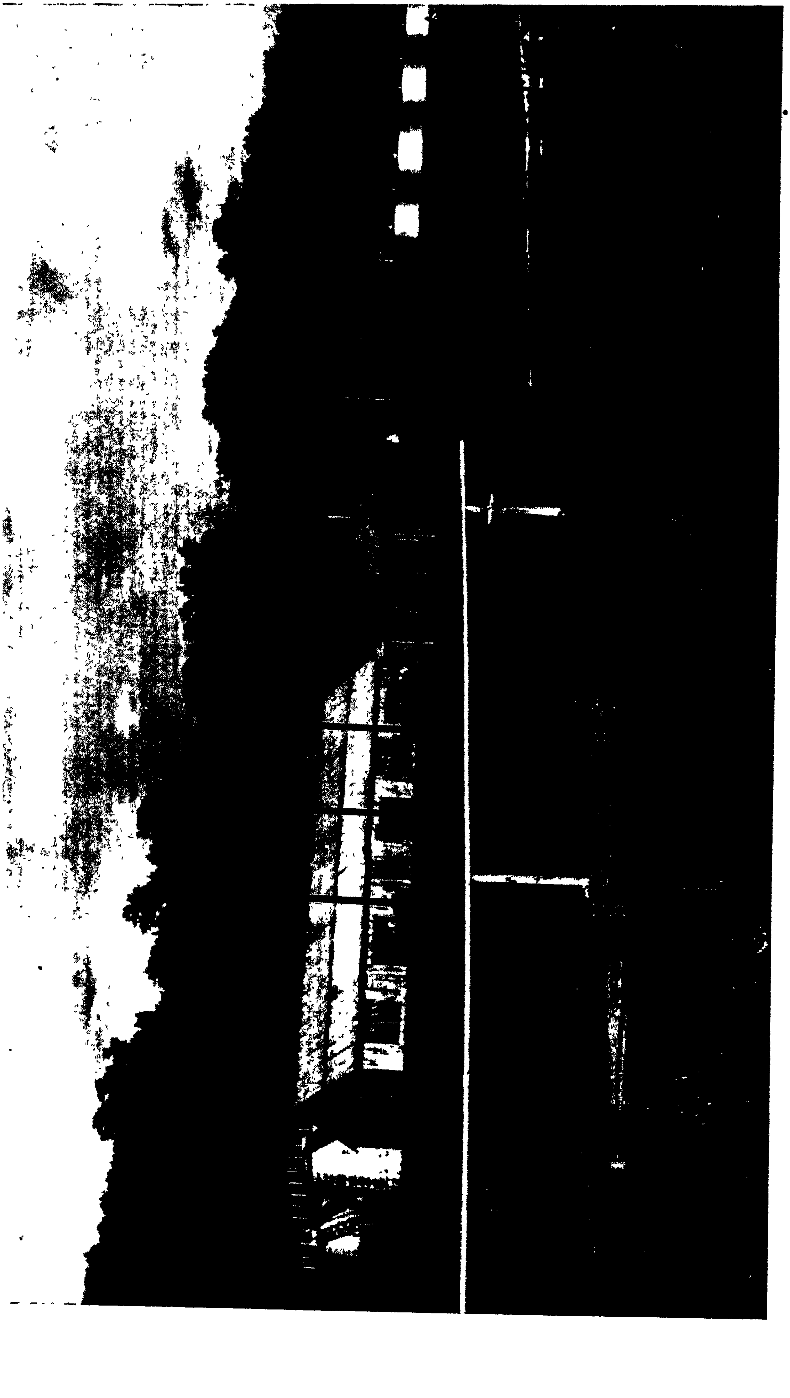

Fig. 12.—A secondary oil recovery operation in eastern Kansas. (Courtesy Brundred Oil Corp.)

of pumping water through input wells down into the oil "sand" with the idea of driving the remaining oil out to other wells from which it flows or is pumped. Either fresh or salt water may be used for water-flooding. Availability usually determines which type is used in Kansas.

Although water-flooding has been employed for 40 or 50 years in the older Pennsylvania fields, it has had official status and sanction in Kansas only since 1935. A law was passed in that year making secondary oil recovery legal in Kansas and placing control and licensing of operators under the Conservation Division of the State Corporation Commission.

Following that development, several water-floods were started in eastern Kansas. The first of official record was by the York State Oil Company in the Seeley-Wick pool of Greenwood County in May, 1935 (Grandone, 1944, p. 1).

From 1935 to January, 1948, the Corporation Commission had issued 304 permits for secondary recovery projects in Kansas. Some of these were for operations in "western Kansas," i.e. west of Butler County. Most of the operations, however, have been in eastern Kansas. Sweeney (*Producers Monthly,* 1948, p. 31) of the Interstate Oil Compact Commission, gives some interesting figures for the principal water-flood counties of eastern Kansas, which are Allen, Anderson, Chautauqua, Franklin, Linn, Montgomery, Neosho, and Wilson. He gives the primary production in those counties through 1935 (omitting fractions) as 111 million barrels; and the production of the same area between 1935 and 1948 as 36 million barrels of which an estimated 12 million barrels have been from water-flood operations. Sweeney estimates that ultimate recovery by water-flooding in these eastern Kansas counties will be about 50 million additional barrels of oil. The State Geological Survey estimates that secondary oil recovery in Kansas during 1947 accounted for the production of at least 4 million barrels of oil.

A recent canvass of secondary oil recovery operations in the State was made by the State Geological Survey. A summary of results is given in Table 19. Greenwood County with 29 water-floods reported and nearly 4,000 acres developed, topped the list of 28 counties. With a total of 25,051 acres under flood by the 166 operations, the average size of the operations would be 151 acres, and 6.6 acres would be the average area covered by each producing well.

Secondary oil recovery is increasing in Kansas. It should be

encouraged because it presents the only presently known method of extracting more oil than can be obtained by primary methods. The technology is being constantly improved.

Table 19.—Secondary oil recovery operations in Kansas, 1948.

County	Number of operations	Number of acres developed	Number of producing wells
Allen	10	507	180
Anderson	6	1,338	533
Barton	1	580	33
Butler	13	2,084	138
Chautauqua	11	3,035	352
Cowley	5	1,890	129
Crawford	2	150+	52+
Elk	3	269	55
Franklin	4	324	120
Greenwood	29	3,960	517
Harvey	4	280	6
Kingman-Pratt	1	1,800	49
Linn	3	236	130
Lyon	2	80	13
Marion	1	80	4
McPherson	13	1,870	103
Miami	9	670	415
Montgomery	22	1,776	580
Neosho	3	729	267
Pratt	1	160	3
Reno	2	200	6
Rice	4	380	15
Russell	6	640	19
Sedgwick	3	330	24
Stafford	5	1,153	26
Sumner	1	160	9
Wilson	1	240	11
Woodson	1	160	3
Total	166	25,081	3,792

Reserves.—The crude oil reserves of Kansas, given by pools in order of their estimated importance, are shown in Table 20. The total figure, about 625 million barrels for the State, does not include reserves of other natural gas liquids amounting to 70 million barrels. Therefore, the total estimated quantity of liquid hydrocarbons remaining in Kansas to be produced by conventional methods may be listed at 695,000,000 barrels.

Mineral reserve estimates are not very meaningful without explanation or interpretation; in fact, they are likely to be misunderstood. For example, it is doubtful whether any informed petroleum geologist or engineer in the country would aver that only 22 billion barrels of oil will be produced in the United States from now on, although that is the estimate of reserves. Divide the 22 billion barrels by current annual domestic production, which is 2 billion barrels, and the result is 11 years. The figure for Kansas is 7 years. Any estimate that oil production in the United States will end or drop off precipitately in about 11 years becomes somewhat absurd in the light of past experience.

Figure 13 shows the relation between annual production and

reserves of crude oil in the United States over a period of many years. One will note that reserves in 1920, in 1930, in 1940, and in 1947 were roughly 12 times the amount of annual production (and consumption) for that year. The ratio changes little. Clearly, it would have been as inaccurate in 1920 to predict the wells would go dry in 1932, as it would have been to predict in 1936 that the wells would go dry in 1948. It would be equally inconsistent to predict now that our oil reserves will be used up in 1960.

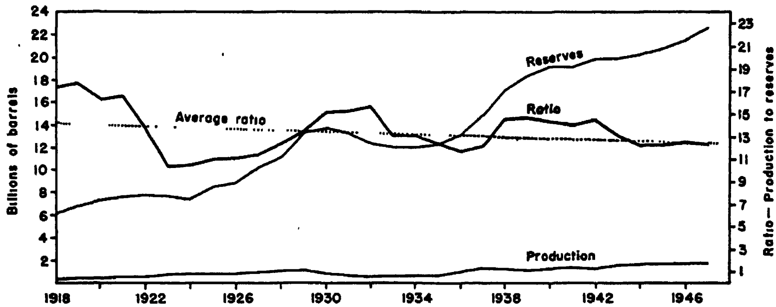

Fig. 13.—Graph showing production and reserve ratio of crude oil in the United States.

When figures for oil reserves are published, it is common to give estimates for quantities of "proved oil." The text of the article in *World Oil* from which Figure 13 was taken states (p. 271), "This figure (i.e. 61.9 billion barrels, estimated world reserves) represents reserves considered to have been actually proved by the drill and does not include a substantial amount . . . as being probable."

From the foregoing and from scrutiny of Figure 13, certain conclusions seem plain:

1. Dividing the figure for oil reserves of a country or state by the current production of the area estimated, gives a misleading and entirely unwarranted conclusion.

2. The oil industry has been maintaining a reserve of crude oil in the ground of roughly a dozen years' production. (That figure probably is accidental.)

3. Although reserves are increasing, there is suggestion of a trend toward narrowing of the ratio between production and reserves.

It probably would be fair to say that most of the cream of the oil in Kansas has been taken. It probably is equally fair to say that Kansas' largest oil reserves remain in the pools that have already been found, in the form of residual oil that must be won by some form of secondary oil recovery. (What portion may be won is entirely problematical.)

The *Oil and Gas Journal* (1948, pp. 225-226) estimate of Kansas crude oil reserves is given in Table 20.

Table 20.—Kansas crude oil reserves, January 1, 1948.
(*Oil and Gas Journal*, 1948, pp. 225-226)

Rank	Pool	Reserves Thousand bbls	Producing wells
1	Trapp	64,691	1,233
2	Silica	32,646	719
3	Bemis-Shutts	30,903	501
4	ElDorado	29,409	1,654
5	Kraft-Prusa	28,749	537
6	Burnett	27,103	230
7	Hall-Gurney	26,055	657
8	Bloomer	17,646	268
9	Gorham	17,111	269
10	Geneseo	15,164	187
11	Chase	13,929	398
12	Stoltenberg	13,070	318
13	Peace Creek	9,630	122
14	Morel	9,241	88
15	Burrton-Haury*	7,933	315
16	Chitwood	6,442	76
17	Ray	5,978	103
18	Bornholdt	5,865	142
19	Edwards	5,802	104
20	Richardson	5,447	60
21	Big Creek	5,441	137
22	Ritz-Canton	5,009	196
23	Carmi	4,901	89
24	Boyd	4,884	30
25	Zenith	4,841	341
26	Crowther	4,329	49
27	Voshell	4,089	68
28	Fairport	3,724	157
29	Hittle	3,667	55
30	Barry	3,519	33
31	Russell	3,444	66
32	Drach	3,202	45
33	Sittner	3,194	54
34	Raymond	2,867	67
35	Lindsborg	2,729	112
36	Cunningham	2,714	121
37	Paden	2,105	46
38	Merten	2,098	55
39	Frog Hollow	1,920	44
40	Lost Springs	1,778	175
41	Forest Hill	1,729	35
42	Miscellaneous	179,009	17,911
	Total	624,000	27,867

*This pool is commonly called simply the Burrton.

The total natural gas reserve that was estimated to remain in Kansas fields as of January 1, 1948, was 14,100 billion cubic feet (*Oil and Gas Journal,* 1948a, p. 170). In this instance, if reserves are divided by annual production — a practice disapproved of above — the answer is noteworthy, being so large, however uncertain it may be. With a current production of nearly 200 billion cubic feet of natural gas a year, the reserves in Kansas would, ostensibly, last 70 years. This calculation disregards a very steep recent upturn of the curve of demand, and the increased rate of use of natural gas for chemicals and other industrial needs.

Trends and Economic Aspects

Certain rather definite trends in the petroleum industry can be noted.

Since more complete figures are published for the entire United States than for any state or area, one can more easily note these broader trends from statistics of the entire industry. The trends, however, apply to Kansas just as they do to the country as a whole. The demand for crude oil, now at an all-time high, continues to increase. Demand for crude in the United States in 1946 was 1.79 billion barrels; for 1947 it was 1.99 billion barrels (*World Oil*, 1948a, p. 73); and for 1948 it is expected to be about 2.1 billion barrels.

The domestic demand for motor fuel alone ranged from 734.8 million barrels in 1946 to 794.1 million barrels in 1947 (*World Oil*, 1948a, p. 73); and it is estimated that it will be about 850 million barrels in 1948. These are peace-time figures, but shortage of automobiles doubtless had some effect on consumption in 1946.

Mainly because of increased industrial demand, the domestic consumption of natural gas recently has shown a higher rate of climb even than has gasoline. From 6 billion cubic feet per day (utility sales) in 1946, it jumped to 6.9 billion cubic feet in 1947, and is expected to reach about 8.2 billion cubic feet per day in 1948.

The shortages of natural gas at times in centers of population and industry in the last two or three winters are expected to be lessened somewhat during the winter of 1948-1949 because of slightly improved pipe line facilities. The shortages will not be eliminated entirely until the pipe shortage is alleviated. There is no present lack of reserves of natural gas in the Mid-Continent gas fields. The difficulty is with distribution capacity.

The ratio of annual production of crude oil to current reserves has been virtually static—approximately 1 to 12—since 1918. This means that the finding of new deposits has just about kept up with withdrawals for use. However, the search for new fields is ever more uncertain, requires ever-increasing technical effort, and is becoming very costly. An increasingly larger portion of the cost of producing a barrel of oil is referable to exploration for new deposits to maintain reserves.

The trend is constantly toward deeper and deeper drilling for oil. Production below a depth of 10,000 feet is common, for example, in Texas although the cost of drilling below 10,000 feet may be several times greater than at modest depths. Drilling will never be

that deep in Kansas because the basement complex on the average, is much shallower than it is in Texas. However, in eastern Kansas the older, pre-Pennsylvanian rocks are being scrutinized now by some of the important companies. It is believed that interesting possibilities remain for modest production in the older rocks in eastern Kansas, where the operators of former years mainly sought shallow production.

At least two wells producing condensate in southwestern Kansas from depths of about 5,000 feet have been reported in recent months. More attention will probably be given in the future to these deeper zones in the edges of the Dodge City basin.

One significant recent development in the petroleum industry has been the marked improvement in production techniques. Heavy acidizing, for example, has been accounting for wells making several million cubic feet of gas per day in parts of the Hugoton field that gave only light wells a few years ago. Unitization in production is a commendable development. The trend toward better production and exploration technology is expected to help in upping or maintaining reserves and to offset in part the seemingly excessive consumption of oil.

It is expected that henceforth, the United States will not quite be self-supporting in respect to supplying its own needs of crude oil. Beginning this year, 1948, the country becomes an importer. (As a matter of expediency oil has been imported from South America, mainly Venezuela, for many years to supply refining stock to permit export of refined products.) Until conditions improve in Europe, the United States will continue to be a larger exporter of refined products.

In conclusion, the outlook for Kansas is that for the foreseeable future, gasoline, natural gas, and petroleum products will cost the consumer more. They will be more readily available than in recent years. Their price will reflect the current trend of cost of labor and supplies, plus the effect of the increasing difficulty of finding new deposits of petroleum. However, the thought may be offered that (barring the effect of wars) no one now living in Kansas should ever suffer serious embarrassment for want of petroleum and its products so long as careful conservation policies are employed in their production and use.

A scientific approach more than ever before is needed now in connection with the exploration, production, and refining of petroleum. It is needed in the conservation of our Kansas deposits.

Research is particularly desirable in connection with secondary oil recovery, which — if its problems could be solved — could immediately double the oil reserves of the entire country.

Basic research on petroleum in general is richly deserved. The best informed students of petroleum do not commonly agree on its origin, which has been a complex problem through the years. Its solution through research may mean much economically.

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The Editor's Page

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ROBERT TAFT, *Editor*

With this issue, the *Transactions* completes its fifth year as a quarterly. Beginning in September, 1944, we have published a number every three months. It is true that on a number of occasions we have lagged considerably behind our scheduled publication dates, but eventually each issue has appeared. We hope that the quarterly *Transactions* has in these five years made a place for itself and that it will continue to do so in the future. As far as the editor can tell, the most popular feature of the Academy quarterly is the section devoted to scientific news notes, and the editor therefore solicits continued aid from his many correspondents in keeping the scientific news of the state up to date.

The *Transactions* reputation eventually, however, will be based on the quality of its reviews and original articles. References to the *Transactions* in other scientific publications and the newspaper press lead to the encouraging conclusion that we are also making progress in this direction. Here again, the editor solicits continued support of the Academy membership in maintaining and strengthening this primary objective of the *Transactions*. Review articles on science and technology within the state are particularly desired and any member of the Academy who has such material in preparation or knows others who possess such knowledge are urged to write the editor. Much of the immediate usefulness of the *Transactions* is based on such articles. Within the past five years reviews on subjects of Kansas scientific interest appearing in the *Transactions* include those on crop industries, animal industries, the salt industry, the petroleum industry, groundwater resources, Kansas lakes, Kansas mammalian fossils, Kansas geography, Kansas wild-life policies, and the Kanza Indians—truly a notable contribution to the scientific literature on Kansas. May we have many more contributions on these lines.

* * *

Mr. Earl K. Nixon, the author of our feature review in this issue of the *Transactions,* is a native Kansan for he was born in Emporia, he was graduated from Eureka High School and for three years, 1913-1916, he attended the University of Kansas. He was graduated, however, from the University of Wisconsin with a major in geology. From

1918 to 1932, he was employed by the M. A. Hanna Company of Cleveland, Ohio, as a mining engineer and geologist and in this capacity traveled extensively in this country and in Canada and South America making explorations and mine examinations and appraisals; included in this interval were two years spent in iron exploration in the Orinico River country of South America. Mr. Nixon's varied scientific career was further extended in the years 1932-37 by work in precious metals mining in British Columbia, California, Montana, and Oregon. From 1937 until 1944, Mr. Nixon served as state geologist for Oregon but he continued to serve in a consulting capacity for geological work in the Yukon, British Columbia, Mexico, and Peru. From 1944 to 1945, he was manager of western exploration for the Freeport Sulfur Company in western states and British Columbia; this interval was followed by two years' exploration for the United States Steel Corporation in Venezuela. Eventually in January, 1947, Mr. Nixon returned to the state of his birth and became geologist in charge of public relations for the Kansas State Geological Survey. With such a record of scientific pilgramage, one would think that Mr. Nixon's taste for travel would be well satisfied but he will be on leave from the Survey during the spring of 1949 to carry out further exploratory work in South America.

MR. EARL K. NIXON

It Hasn't Changed Much in 400 Years

As concerning football, I protest unto you that it may rather be called a friendly kind of fight than a play or recreation — a bloody and murthering practice than a fellowly sport or pastime.

—*Phillip Stubbes, 1583*

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

Dr. J. C. Peterson, president of the Kansas Academy of Science in 1947-48 and professor of psychology at Kansas State College, Manhattan, is on leave of absence during the present school year. During this interval, Dr. Peterson will serve as associate director of the instructor training division of the U.S. Air Force Special School, Craig Field, Alabama. Dr. Peterson and his staff will conduct a continuous review of the curriculum in the instructor training division, and suggest new tests and techniques in the development of training courses.

Professor J. M. Berkebile, head of the chemistry department of McPherson College, is absent on leave during the current school year and is continuing his graduate studies at Ohio State University, Columbus. In his absence, Dr. L. V. Heisey, who joined the McPherson college staff last year, is acting head of the department. Miss Ida M. Young of Petersburg, Va. has joined the science staff as assistant professor of chemistry and mathematics.

Dr. Heisey, who received his doctorate from Purdue University in 1947, has recently published (July, 1948) an article "Monomers and Polymers: Vinylthiophenes" in the *Journal of the American Chemical Society.*

It has recently been announcd that the department of physics, Kansas State College, Manhattan, will offer work leading to the doctorate in physics. Work will be offered in electricity, electronics, some phases of nuclear physics, theoretical physics, and in X-ray, infra-red, visible, and ultra-violet spectroscopy. The department is one of the organizations participating in the work of the Argonne National Laboratory, Chicago.

Recent additions to the science staff of Baker University, Baldwin, include Mr. Ralph S. Ring in engineering drawing and Mr. Donald M. Hester in mathematics.

Dr. L. D. Bushnell, past president of the Academy and professor of bacteriology at Kansas State College, Manhattan is carrying out an investigation on Newcastle Disease Virus. This disease of chickens which is now spreading rapidly over the U. S. A. was described first in Californa under the name of pneumo-encephalitis because the symptoms are first gasping for air followed in a few days by extreme nervous symptoms. The diagnosis consists in the isolation of the virus during the early stages by injecting 10-day chick embryos with infectious material or by use of the hemagglutination inhibition test. The New-

castle Disease virus agglutinates chicken red blood cells in high dilution. As the birds recover they develop high titer antibodies in the serum. Such serum will neutralize the virus and thus inhibit the agglutination. This points to a past infection. Factors which influence this last reaction are now being studied.

Recent additions to the faculty of biological sciences at Fort Hays Kansas State College, include Henry J. McFarland, Edwin P. Martin, and James R. Wells. Mr. McFarland received a B.S. and a M.S. from Emporia State Teacher's College, and he has also attended the University of Colorado and the University of Oklahoma. In addition to several years in Kansas high schools, his teaching experience includes positions on the faculties of Nebraska State Teacher's College at Peru, Nebraska, and Oklahoma City University.

Mr. Martin, whose responsibility is primarily in zoology at Fort Hays State, received an A.B. from Cornell and a M.S. from Kansas State College in Manhattan. During the last year he was a graduate assistant at Kansas State College, Manhattan. Mr. Wells is assistant farm superintedent, and has taught vocational agriculture for a number of years in Waterville and Ellis High Schools. He is instructor of courses in livestock and farm machines. He received his A.B. and M.S. from Kansas State College, Manhattan.

Mr. Harold Hopkins of the botany department will return to Fort Hays in the fall of 1949, after having completed the requirements for his doctor's degree at the University of Nebraska.

Mr. Byron Blair, formerly research assistant in the botany department of Fort Hays Kansas State College, has accepted an appointment with the Southwestern Forest and Range Experiment Station, Tucson, Arizona.

Mr. Gerald Tomanek, of the biological science staff, completed one summer's work on his doctor's degree in 1948 at the University of Nebraska, and will continue his work during the summer of 1949.

Mr. Homer Elling of Manhattan, Kansas, has joined the staff of the University of Wichita Foundation for Industrial Research. Mr. Elling who has received his master's degree in milling chemistry from Kansas State College, will direct and carry out work for the Foundation on cereal chemistry and milling processes.

A conference on methodology and techniques for the study of animal societies was attended on November 12-13, 1948, by Dr. A. M. Guhl of Kansas State College, Manhattan, and secretary of the Academy. The meetings were held at the American Museum of Natural History and the Bronx Zoological Park, New York City, and were sponsored by the New York Academy of Sciences and the New York Zoological Society. This relatively small group was composed of behavior students, parasitol-

ogists and other zoologists, anthropologists, psychiatrists, and mathematicians. It is of particular interest that a variety of interests found a common ground and were effectively utilized in a cooperative approach to the study of behavior. The conference was arranged by the committee for the study of animal societies under natural conditions.

Dr. R. R. Dykstra, dean of the school of veterinary medicine, Kansas State College, Manhattan, has retired after thirty-seven years' service at the College. Dr. Dykstra has been succeeded by Dr. E. E. Leasure, since 1926 a member of the veterinary medicine staff.

The department of entomology, Kansas State College, Manhattan, reports on its current activities as follows:

New staff members for the fall semester include Dr. Philip F. Bonhag, assistant professor, who received his Ph.D. at Cornell in August and is a specialist in insect anatomy; Mr. Roland L. Fischer, graduate assistant, who has his bachelor's degree from th University of Michigan and master's degree from Michigan State College; Mr. James Wick, graduate assistant, with a bachelor's degree from Iowa Wesleyan College; Mr. Dell E. Gates, graduate assistant, who has received his bachelor's degree from Kansas State College. Mr. James B. Kring is also a graduate assistant in entomology. He took his master's degree in this department last June and is a candidate for the doctorate.

Dr. R. H. Painter, professor of entomology, is on sabbatical leave and has been awarded a post-doctoral fellowship at Ohio State University for the school year 1948-49. He and his family went to Columbus, Ohio, early in September and he is now engaged in writing a book on insect resistance in plants. He will incorporate much of his own research in this book.

Dr. George A. Dean, who became professor emeritus of entomology several years ago, has been relieved of teaching this year and is spending the time when in his office assisting with the work on Project Number 281 "Climatic Factors on Insect Life," of the Experiment Station and in constant consultation with students and staff members. His health has been excellent.

Dr. E. G. Kelly, extension entomologist, is critically ill at this writing, November 20th, of coronary thrombosis.

Mr. Leonard M. Redlinger, who has one year beyond his master of science degree (Kansas State College) was appointed entomologist, Bureau of Entomology and Plant Quarantine, at the Manhattan Laboratory July 1st. His investigations deal with the control of insects in farm-stored grain. This work is being done on a research and marketing project.

Mr. Marvin M. Dennis, who has his bachelor's and master's degrees from the University of Florida, joined the staff of the Manhattan laboratory of the Bureau of Entomology and Plant Quarantine in May, 1948. His investigations deal with grain fumigation and residual sprays.

The Kansas Termite and Pest Control Association, which was organized in February of this year, held its fall meeting for the election of officers at Kansas State College on November 9th. Mr. Raymond Schuyler, Kansas City, Kansas, was re-elected president and Mr. H. L. Davids of Wichita was elected secretary-treasurer. The organization expects to use its influence to improve the quality of termite and pest control services provided in the state and to see that operators in these fields are better informed about latest successful practices.

Dr. Roger C. Smith, professor and head of the department of entomology at Kansas State College, will attend the annual meetings of the national entomological societies in New York City, December 13th to the 16th inclusive. He will speak on "Better Academic Preparation" in the teaching section.

Kansas Wild Flowers by William Chase Stevens, University of Kansas Press, Lawrence, Kansas, 1948, 463 pages, $7.50.

It is refreshing to find a distinguished plant scientist, who, upon retirement from a long and inspiring career, takes up an arduous, time-consuming field study. Such a man is Professor W. C. Stevens of the University of Kansas. Since his retirement, he and his wife have spent a dozen years travelling over Kansas with camera and trowel, accumulating the photographs with which he has illustrated his book.

Taking advantage of previous basic publications on the flora of Kansas, Professor Stevens sought to bring to the printed page lifelike characterizations of the majority of the plants of Kansas which are commonly designated as wild flowers. Altho many of these plants do occur also in surrounding states, this is a book particularly for Kansans to be proud of, done by a Kansan, utilizing Kansas material and printed by a Kansas press.

Excluding the grasses, which most folks do not consider as wild flowers, a majority of the wild flowers of Kansas are portrayed as only a camera in the hands of a patient naturalist can achieve. Botanical keys are often provided to separate species when specific differences cannot well be shown in a photograph. Habitat pictures are occasionally used to bring out mass effects of some species additional to the picture of individual specimens.

Specimens photographed have been particularly well chosen to bring out features for recognition. The individual specimens have often been placed on a grid of inch squares to give size as well as appearance. This aid makes the book especially valuable, not only in the hands of the amateur, interested in knowing of our plant wealth, but also to the professional, who is used to reading word descriptions only.

The vexatious problem of what common name to use, where so many are available and so many are so often misapplied, has been handled with discernment and compromise. Fortunately the scientific name accompanies all species.

The use of double columns makes for a most attractive page which is easy to consult. Notes on the uses of the various species by Indians and others, medicinal values, poisonous qualities and interesting bits of information make it a book to read as well as to study.

The book, itself, is embellished with a frontispiece of sunflowers in color. It contains a preface in which the author is most generous with acknowledgements; an introduction in which the author gives fundamental facts and terminology about plants in general; discussion of Kansas prairie and physiography; a key to the families of flowering plants; followed by 761 photographs by the author and descriptions of about 500 Kansas wild flowers, arranged in accordance with the natural system. Several drawings of parts, a glossary and an index are also included.

Since Professor Stevens states that the state has been "alerted" to its native flora thru publications of Frank C. Gates, I am certain that Professor Stevens, himself, has now made more interesting the study of the wild flowers, which grace our prairies and woodlands, thru his splendid and accurate photographs. — Frank C. Gates.

Walter Fleming, formerly of the University of Manitoba, is now assistant professor of mathematics at Fort Hays Kansas State College. He received an M.A. degree from the University of Minnesota in 1944 and has pursued further graduate studies there.

Harlan B. Johnson has been added to the teaching staff of the chemistry department of the Fort Hays Kansas State College. Mr. Johnson has his B.S. from Purdue University and his M.S. from Iowa State College. He has had industrial experience with the Eastman Kodak Company, Rochester, N. Y., the Tennessee Eastman Corporation, Oak Ridge, Tenn., and Eli Lilly and Company, Indianapolis, Ind.

The Fourteenth Biennial Report of the Director of the Kansas Agricultural Experiment Station, which will contain a brief statement on the objectives and results of all of the research projects underway at the Experiment Station, will be issued in January, 1949.

In our issue for December, 1947, we published enrollment data for the 42 junior and senior colleges of the state. The information there given proved to be of so much value and interest that we have compiled, with the kind co-operation of the 42 college registrars of the state, enrollment figures for the current year. The enrollments for both years is published in the accompanying table. It would appear from the figures here tabulated that college enrollments in Kansas are leveling off, the total figure for 1948 being lower by less than a half of one per cent than the figure for 1947. It is to be noted, however, that while small relative gains have been made in senior college enrollments in 1948, junior college enrollments have decreased by about 14% from the enrollment in 1947.

ENROLLMENTS IN KANSAS SENIOR COLLEGES

	Fall, 1947	*Fall, 1948*
1. Baker University, Baldwin	640	667
2. Bethany College, Lindsborg	420	406
3. Bethel College, North Newton	439	416
4. College of Emporia, Emporia	312	335
5. Fort Hays Kansas State College, Hays	981	979
6. Friends University, Wichita	576	525
7. Kansas State College, Manhattan	7,158	7,432
8. Kansas State Teachers College, Emporia	1,362	1,441
9. Kansas State Teachers College, Pittsburg	1,899	1,844
10. Kansas Wesleyan University, Salina	515	529
11. McPherson College, McPherson	459	408
12. Marymount College, Salina	266	265
13. Mt. St. Scholastica, Atchison	401	394
14. Ottawa University, Ottawa	580	583
15. St. Benedict's College, Atchison	486	529
16. St. Mary College, Xavier	375	370
17. Southwestern University, Winfield	701	608
18. Sterling College, Sterling	321	273
19. Tabor College, Hillsboro	352	237
20. Washburn Municipal University, Topeka	1,919	2,020
21. Wichita Municipal University, Wichita	3,032	3,164
22. University of Kansas, Lawrence and Kansas City	9,486	9,751
Totals	32,680	33,176

ENROLLMENT IN KANSAS JUNIOR COLLEGES

1. Arkansas City	236	215
2. Central College, McPherson	105	105
3. Chanute	242	220
4. Coffeyville	482	361
5. Dodge City	219	205
6. El Dorado	281	223
7. Fort Scott	267	200
8. Garden City	129	151
9. Hesston	187	113
10. Highland	96	68
11. Hutchinson	476	430
12. Independence	300	244
13. Iola	92	90
14. Kansas City	684	548
15. Paola (Ursuline College of Paola)	104	120
16. Parsons	266	239
17. Pratt	125	152
18. Sacred Heart, Wichita	81	70
19. St. John's Lutheran College, Winfield	257	226
20. St. Joseph's, Hays	21	25
Total Junior College Enrollments	4,650	4,005
Total Senior College Enrollments	32,680	33,176
Grand Total, College Students in Kansas Colleges	37,330	37,181

One of the most recent and most arresting items in the growing volume of literature about conservation of natural resources is the book, *Road to Survival,* written by William Vogt and published in 1948 by William Sloane Associates, New York. The retail price is $4. The book's 300 pages are replete with factual data and tough-minded comment regarding the world's resources (particularly those on which we depend for food) and

the growing pressure of population on these resources. Our living standards, the author shows, are largely dependent on a proper balance betwen natural resources and population; but, he contends, the two are increasingly out of balance and living standards are correspondingly endangered. Many striking instances in support of the author's thesis are described.—F. D. Farrell.

Two-hundred and eighty-eight Hereford steer calves were recently sorted and shipped from Sheridan, Wyo., for a new experimental feeding project in which the Kansas, Oklahoma and Ohio Experiment Stations are cooperating. Each station received 96 calves which were secured from the following commercial Hereford herds in that locality: Bar 13 Ranch, PK Ranch, and O. M. Wallop from near Sheridan; and M. C. Simpson, Volborg, Mont. The calves were chosen as a result of earlier inspections on the basis of large, medium and small sized breeding animals in the herds from which they came. The calves of large size averaged 440 lbs., medium size, 412 lbs., and the small size, 396 lbs. in weaning weights. With the exception of 25 head of small calves which had to be purchased at a premium price in the auction sale held in connection with the Sheridan, Wyo., feeder calf show in order to obtain the number of small calves of similar breeding required for the experiment, all of the calves were bought at the going market price of choice, range-bred steer calves.

Each of the three experiment stations will conduct the same type of test in which calves of small, medium and large sizes will be compared in three distinct beef production systems. The Group I calves, including ten small, ten medium and ten large individuals, will be full-fed for 225 days, then marketed and slaughtered and carcass data secured.

Group II, including the same number of each size of calves, will be rough-wintered on a silage and light grain ration, grazed 100 days, full-fed 100 days and marketed; after which slaughter and carcass data will be secured.

Group III, also including ten small, ten medium and ten large calves, will be rough-wintered, grazed throughout the following summer, rough-wintered the second winter, and grazed the second summer. They will be marketed as grass-fat steers at the end of the grazing season of 1950 when about thirty months of age. Slaughter and carcass data will also be secured on this group.

The rest at each of the three stations will be handled in the same general manner except that the grain rations used are to be similar to the usual feeding practices of the respective states. While the experiment has been made possible because of grants from the American Hereford Association, Kansas City, Mo., control of the test is entirely in the hands of the experimental stations with Dr. A. E. Darlow in charge at Stillwater, Okla., Dr. A. D. Weber in charge at Manhattan, Kan., and Prof.

Paul Gerlaugh in charge at Wooster, Ohio. At the conclusion of the experiment, a joint report is to be issued by the three cooperating stations.

It is hoped this new and cooperative study will supply breeders and feeders with new factual and practical information on the relation of size to economical beef production and the value of the beef product. The fact that it includes three systems of management and is being done in triplicate should speed the yield of worthwhile facts as compared to the average beef cattle experiment.

Dr. S. A. Edgar, a former member of the Academy and now a member of the agricultural experiment station, Alabama Polytechnic Institute, Auburn, Alabama, has been granted a year's leave of absence to serve with the U. S. Public Health Service on the French Society Island, Tahiti, in the Southwest Pacific. Dr. Edgar will be associated with a group of scientists working on a research project which will attempt to find the species of mosquitoes which transmits filarisis, commonly known as elephantisis, and to determine the best methods of controlling this disease.

The 900-page *Yearbook of Agriculture*, 1948, is devoted to the subject of grass. It contains 128 papers by authorities on various phases of the subject, 65 pages of charts and tables, a 32-page list of the common and the scientific names of grasses and a very large number of drawings, graphs and excellent reproductions of photographs, many in color. The word grasses is used in a general sense, for the book contains much helpful information about some plants that are not grasses but are often associated with grasses in one way or another; such plants as the legumes and certain poisonous species. The volume is a treasure house of information for those who grow, process or use grass, for those engaged in any research directly related to the grasses, and for those who are interested in the vital role of the grasses in the development of our agricultural industries and, indeed, of our civilization. For Kansans, particularly, not the least interesting chapter is the reproduction of John J. Ingalls' "In Praise of Blue Grass", from the *Kansas Magazine* of 1872. The Yearbook may be obtained from the Superintedent of Documents, Washington 25, D. C., at $2.00 a copy, which is a small fraction of its cost and a still smaller fraction of what it is worth.—F. D. Farrell.

Professor C. D. Davis of the farm crops division, Kansas State College, Manhattan, has retired after 27 years' service to the state. Not content with his retirement at Kansas State, however, Professor Davis, during the current year, is teaching courses in cereal crops and in general crops at Colorado Agricultural and Mechanical College, Fort Collins.

Three graduate fellowships, given by the University of Wichita Foundation for Industrial Research and paying a stipend of $1000 each, plus tui-

tion and fees, have been awarded for the current year to Wayne Cassatt, *chemistry*, John Nunemaker, *aeronautical engineering*, and A. J. Napier, *petroleum geology*. Cassatt and Nunemaker are both graduates of the University of Wichita and Napier of the University of Kentucky.

Publications of the State Geological Survey, University of Kansas, Lawrence, announced since our last issue, include:

Bulletin 73 *Geology and ground-water Resources of northern Cloud County, Kansas*, V. C. Fishel, 194 pages; 25 cents mailing charge.

Kansas Rocks and Minerals, Laura Lu Tolsted and Ada Swineford, 56 pages. This booklet is a most interesting popular description of Kansas geology and minerals. Interest and value is added to the booklet by numerous diagrams and photographs. Members of the Academy interested in geology should write without delay for their copy. A five cent mailing charge will bring it.

Dr. A. B. Leonard of the department of zoology, University of Kansas, who is on leave during the current year, has prepared, at the request of the editor, the following interesting account of his activities during the fall:

Mr. Austin B. Williams and myself spent a month, beginning August 15, in the Ozark Highland, collecting aquatic mollusks and crayfish. I returned to the region after Mr. Williams found it necessary to return to school, and continued collecting crayfish, aquatic mollusks, and terrestrial mollusks. Altogether, we traversed the Ozark Highland and the adjacent Ouachita Mountains, six times in an east-west direction, with about four north-south traverses, totaling about 7,000 miles. We think we have the most complete collection of crayfish ever taken from the region, and the same holds true for aquatic gastropods. Much work remains to be done on the terrestrial gastropods.

Mr. Williams has about 250 lots of crayfish from the region, and I have a similar number of lots of mollusks. The crayfish will be studied by Mr. Williams as a part of a doctorate dissertation; the mollusks will be studied by myself, as a zoogeographical study of speciation in this dissected plateau.

The geology section of the Academy has planned the following program for the 1949 meeting in Manhattan:

Friday morning.—General papers.

Friday afternoon.—Symposium on current trends in geology; this will include 20-minute talks by specialists in various fields of geology on the present status and probable future developments in each field. Ground water, state surveys, highway geology, reclamation geology, petroleum geology, and military geology will be the phases covered.

Saturday morning.—A field trip through Pottawatomie and Wabaunsee Counties to inspect the glacial geology displayed there.

It is hoped that those planning to present papers will contact the section chairman, Frank Byrne, Kansas State College, as soon as possible.

The department of geology of Kansas State College, Manhattan sends the following interesting news items for the current

issue of the *Transactions*s

The department lost John W. Branson, assistant professor, to the petroleum industry but retaliated by enticing Charles Phillip Waters from that same industry. Mr. Waters holds the rank of assistant professor.

Melville R. Mudge, until recently a graduate student in the department, has been appointed geologist with the United States Geological Survey. Mr. Mudge is the great-grandson of Benjamin Franklin Mudge, one of the founders of the Kansas Academy of Science.

A. B. Sperry, head of the department, is continuing his intensive studies of clay minerals. It is hoped that a preliminary report on this important aspect will be presented at the 1949 meeting.

Th Alpha Nu chapter of Sigma Gamma Epsilon, honorary fraternity of the earth sciences, entertained the Alpha chapter of the University of Kansas with a field trip and buffet lunch the morning of the annual K.U.-K-State football game. It is hoped that each such football game in the future will be the occasion for a similar event at K.U. one year and K-State the next. For some reason unknown to the editor, the Kansas State contigent enjoyed the field trip more than it did the football game.

Karl Stacey, associate professor of geography at Kansas State College, has high hopes for developing a full schedule of papers to be presented to a geography section of the Academy this coming spring. Geographers in the state are urged to contact Professor Stacey.

Denzil W. Bergman joined the geology staff this fall as instructor. Mr. Bergman is a graduate of Kansas State College and will receive his Master's degree from the College this spring. Mr. Bergman was employed by the United States Geological Survey during the summer session.

The Department of Geology now has an enrollment of more than 160 major students.

Percentage Distribution of 668 Faculty Salaries (nine months) in 29 Collegiate Institutions*.

Sex	Average Salary	Under $1750	$1750-3499	$2500-4999	$5000-7499	$7500 and Over
Men	$4,052	0.5%	2.9	25.6	34.9	1.3
Women	$3,099	0.2%	4.7	8.1	5.3	--

—Higher Education for American Democracy, volume VI, 1947.

*State universities, land-grant colleges, municipal colleges, liberal arts colleges, technical schools, teachers colleges, junior colleges, negro colleges, women's colleges, and men's colleges were included in the survey. More detailed figures are given in the report cited above, p. 41.

Presidential Address

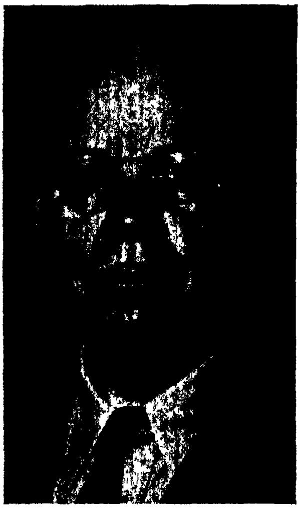
Kansas Academy of Science

1948

Some Factors and Pitfalls in the Application of Knowledge

J. C. PETERSON
Kansas State College, Manhattan

Current stresses, strains and discontinuities in science may well be regarded not as threats of disintegration into diverse and relatively independent fields, but as youthful growing plans attesting the fundamental unity of all science. Our symposium this afternoon was a planned *drawing* together of scientists from various fields of specialization in order that we might learn to *pull* together more effectively towards common goals. The goals in view were not so much those of increased production of goods as of improved understanding of possible contributions of science to adaptive social development and organization, in line with the nature and fundamental needs of the individual in a rapidly changing environment.



DR. J. C. PETERSON

The application of scientific discoveries can be classified broadly though not sharply into three categories with respect to the nearness of tangible goals: (1) those which lead directly to the production of consumable goods, (2) those which result in the improvement of materials, tools and instruments of production and further discovery and (3) those which contribute directly to social development and organization through symbolic learning.

A majority of the applications of scientific discoveries belong to the first classification and are made for profit by men who know little and care less about the far-reaching social or biological effects of their innovations. Most of these effects are unintentional and unforseen. But the methods of production, distribution and con-

sumption often lead to new human contacts and relations which may undermine institutions so as to bring about fundamental changes in social structure and organization. For example, the minute specialization required by mass-production forces countless workers into endless repetitive mechanical motions which eventually rob men's working lives of human warmth and meaning. The nature and consequences of such monotony was aptly characterized by a worker who complained: "I keep forever screwing on Nut number 999 until finally I become Nut number 999."

This problem of industrial monotony is a social ailment for which no effective remedy has yet been found. Numerous palliatives such as shorter work days, longer week-ends, higher wages, recreational facilities etc. are being applied but science is likely further to aggravate this disorder before finding a cure. It is useless merely to treat the symptoms. Thorough analysis and diagnosis is required and this is largely a psychological problem. No doubt more searching job analysis and worker analysis will reduce monotony by a better matching of job requirements with the abilities and interests of workers. It has been suggested that simple repetitive jobs should be filled by workers of low mentality. One prominent scientist with whom I discussed this matter recently, admitted the constant increase of mechanization in industry and also the high birth-rate among people of low-grade mentality; but, he commented, "I see nothing wrong with this situation. Industry must use mass-methods to produce the goods we need. To do this the employer must find innumerable workers of low-grade mentality. Industry can employ all the morons we have and more. God bless the morons and multiply them." Doubtless we all agree with the first of these pious invocations, but surely the second would signify an abject surrender of men to machines. Over a long period such a surrender could eventuate in the machine making man over in its own image. Remember Nut number 999. The problem of industrial monotony is a vital threat to mental health and social stability. This challenge is big enough for the best brains in organized labor, industry, technology and all the related fields of science. Perhaps organized labor could begin its contributions by removing some of the restrictions which forbid a single worker to go through all the motions necessary in a simple task like the installation of an electric light or switch. Such arbitrary division of labor does seem a bit burdensome and monotonous when one specialist is required for moving a ladder, a second

specialist for driving a nail and a third for screwing a light bulb into the socket.

The application of scientific discoveries to the development of new instruments of research and further discovery, the second category of the foregoing classification, is peculiarly the scientist's province. Each new success in this field lays the foundation for further specialization in science and increases the need and reward for cooperative planning and team work among scientists in different fields.

Applications of science that contribute directly to social development through symbolic learning, the third category in our foregoing classification, are primarily the responsibility of the social and biological sciences. Speaking of this matter Alfred E. Emerson[3] says: "Man transcends the highest vertebrates in his ability to communicate by means of symbols and to transmit the experiences of one generation to the next by use of these symbols, thus building up a social heredity distinct from his germinal heredity . . . . . . As a result of learned behavior and symbolization, great complexities of social interaction occur in human society not manifest in other societies." Among these complex interactions he mentions, education, religion and political ideologies. In the latest issue of Science, F. S. C. Northrop[8] also stresses symbols as means of applying knowledge to social development and control. "What specifically", he asks, "does it mean to assert that human behavior and its attendant social institutions are significantly determined as to their form by ideas? For one thing, it means that human beings in society are reacting not merely to particular natural events occurring just once at a given time and place, but also to symbols, to socially conditioned symbols, which keep their meanings constant during the period of decades or centuries, as the case may be, in which a given normative social theory captures their faith and thereby serves as a norm for their social behavior and cultural institutions".

An analysis of the application of knowledge may be made from the viewpoint of the history of science and philosophy, or it may be made on a small scale by putting men to work on definite objective problems of limited scope and observing their problem-solving behavior by experimental techniques and procedures. Here as in history we can see bits and systems of knowledge emerge and find application in fuller and more minute analyses of the situation from which they arose or in problems of theory or action. Here we can see the nature of the leads by which new analyses, concepts, techniques and

procedures are originated and tested. Here likewise we see some of the false leads, hunches and partial insights that constitute the pitfalls which one must learn to avoid or escape if he would engage successfully in the application of knowledge either to the discovery and organization of new knowledge or to the invention and production of new goods and gadgets.

The possibility of such a brief, thorough, and objective experimental analysis of thought came to me first many years ago when after dinner my host entertained some of his guests with an intellectual puzzle game which he had picked up that day from a traveling salesman. Putting down 14 matches, he said to me in substance: "Your problem is to draw the last match. We draw alternately taking either 1 or 2 matches at any draw. You draw first and you can always win if you take the correct number of matches at each draw."

I have since analyzed and expanded this problem into many series of problems varying in complexity and so related and arranged that the solution to each problem or series constitutes a good first step towards the solution of subsequent problems[10]. The solution to each problem is a generalization which though adequate for the current problem is usually too narrow to serve for succeeding problems. The solutions to successive problems form a series of higher and more inclusive generalizations until finally a universal solution is obtained which applies to all problems of this kind.

Scores of capable thinkers have played these games with me while I recorded each response numerically, often including a measure of the time required for each separate overt response. Various analyses of these data agree in the main with systematic analyses of the discoveries of science. To provide a common basis for our discussion of the problems of analysis, generalization and application of knowledge I would like each of you to become a voluntary guinea pig for the next few minutes. This can be fun if we don't take it too lightly or too seriously and it can pave the way for our thinking about thinking now and later.

To participate in this fun you will need 14 matches each. But perhaps in this non-smoking audience we had better do it with dollars. To provide a stake for each of you to defend, will you each put up seven dollars. Pile them up in an imaginary stack right there in your mind's eye and I will add seven dollars more to each stack.

Remember that your problem is to draw the last dollar. Do that and you win all. We draw alternately taking either 1 or 2 dollars at any draw. You always draw first and can always win if you take

the correct number at each draw. Now, with a stack of 14 imaginary dollars before you, you cast about for ideas by which to exercise remote control over the last draw which is at least 12 dollars and ten draws removed your present stance. The remoteness of the goal or final draw tends to prevent clear perception of relevant details and all but force you to the higher numbers which are immediately before you. So, after the manner of Descartes, you proceed by calling up all the seemingly relevant concepts and generalities you can think of, try them out one at a time and throw out all you can possibly doubt. Thus you call up the ideas of odd numbers, even numbers, alternate odd and even numbers, unlucky numbers, high draws, low draws, opposites, etc. Each of these ideas seems to work at times and fail at others without rhyme or reason. Because you know too little about the situation, you cannot therefore wholly accept or reject any of them. In short, for the reasons given above, you do not readily succeed with the deductive method of Descartes.

You may then proceed by Francis Bacon's method, discarding all preconceived ideas, formal logic, etc., and direct your attention to the observation of facts and their relations for, as Bacon says: "axioms duly and orderly formed from particulars easily discover the way to new particulars and thus render science active". But you still have the problem of deciding to what facts and particulars attention shall be directed and how.

Here John Dewey's conception of analytical thinking and his means of directing attention to the crucial points of a problematic situation are very helpful. To Dewey the starting point of analytical thinking is always an obstructed purpose. The next step is the location and definition of the difficulty which is obstructing progress towards the goal. This clarification of the difficulty tends to direct attention to a minute analysis of the relevant details of the problematic situation and their relationships, and may include reformulations of the problem in clearer and more objective terms. Direct and repeated observation of relevant particulars and their recurrent relationships may either call to mind by associations previously formed, appropriate concepts, or it may bring about a gradual adjustment of previously inadequate concepts, or of appropriate new concepts with which further to analyze the situation and formulate trustworthy generalizations.

There is another general factor of learning and motivation which is of great importance here. This is the factor of the clearness and immediacy with which the learner is able to perceive the consequences

of each unit of response. It is the immediate check-up of the correctness or incorrectness of each response through its sensory consequences. This factor explains the facility with which a child learns to avoid contact with a redhot stove and the slowness or absence of his learning to avoid eating green apples.

With these two factors in mind let us now turn back to our problem. The statement of this problem begins with the attention-directing reminder: "Remember that your problem is to draw the last dollar". An occasional learner will say: "All right let us look at that last dollar and see the immediately preceding situation from which we arrive at it. If you leave me one dollar, I take it. If you leave two, I take them both. If you leave me three, I can't win because if I take one, you will take two and I lose; if I take two, you will take one and I still lose. That was three dollars and I lost. Perhaps if I force you to draw from three, I can win". He checks and finds that he is right. Then he continues: "How can I force you to draw from three? If I leave four, you can take one and win by forcing me to draw from three. If I leave five, you can win by taking two and forcing me to draw from three. If I leave you six, I can force you to draw from three, so I win. To force you to draw from six, I must leave you nine so that whether you take one or two, I can draw such a number as to leave you six. Three, six, nine—those numbers are multiples of three. Apparently I can win any number which is not a multiple of three by drawing so as to leave you a multiple of three after my first draw and after each of my succeeding draws down through three to zero which is also a multiple of three".

This analysis is correct and applies perfectly to all problems in Series 1 to 2, that is, to all problems in which only 1 or 2 dollars may be taken at any draw. But suppose we now complicate the problematic situation by presenting a problem from Series 1 to 3. In this series either 1, 2, or 3 dollars may be taken at any draw. You still have 14 dollars and the rules are the same as before except that you may now take either 1, 2 or 3 dollars at any draw and so may I. What did we learn from Series 1 to 2 that may be applied to the solution of our present problem in series 1 to 3? The discovery that the number *3* and all its multiples are critical, i.e., insoluble numbers, plus the further discovery that you can win all non-critical numbers by drawing so as to force me to draw from the critical numbers may serve to direct our attention in this new problematic situation. At this point word troubles begin to arise.

The critical number *3* which we shall designate by a capital C

may be conceived in several different ways of which we shall consider three, namely (1) C equals 1 plus 2; (2) C equals L plus H (*L* being the lowest possible draw and *H* the highest); (3) C equals the sum of all possible draws, that is, 1 plus 2 in Series 1 or 2. Which of these conceptions is right? They all work satisfactorily for any problem in Series 1 to 2. Will all of them work in problems of Series 1 to 3 to which our present problem belongs? Obviously not for if you apply the analysis listed in (1) above, you will leave me 3 dollars and I will win by taking them all. This analysis is here generalized in terms that are too restrictive for application to problems in series 1 to 3 because they exclude *3* as a possible draw.

The analysis listed in (3) above is generalized in terms that for series 1 to 3 are too inclusive because they include the sum of three draws whereas only two draws can enter into a pair whose total can be controlled by the player who draws last. This is a case of over-generalization which is extremely hard to detect while working in the simple situations presented in problems of series 1 to 2. It is a type of error which is likely to occur whenever an attempt is made to apply discoveries arising from the analysis of a simple situation to the analysis of a more complex situation. The operation of this source of over-generalization may be expected whenever the findings of research on a simple organism are in process of being applied to a more complex organism or from a relatively simple structure or function to more complicated ones in the same or different species. For example, the discovery that certain factors control the color of eyes in Drosophila cannot safely be applied directly to the inheritance of mental traits and functions in man. This does not mean that such direct applications are necessarily wrong. It does mean that they are unsafe until checked by further experimental analysis in the new field to which they are to be applied.

Let us return briefly to the analysis of Series 1 to 2 which is listed in (2) above. Here the critical number 3 is conceived as the sum of the lowest plus the highest possible draw, i.e., L plus H and all multiples of 3, i.e., n (L plus H) are also critical numbers. This formula applies perfectly to Series 1 to 3 and, indeed, to all series where the possible draws include all consecutive, whole, positive numbers from L to H inclusive. In our present problem of 14 dollars, Series 1 to 3, the critical numbers are multiples of four and your first draw is correct if you take 2 dollars.

Without further illustration from the almost inexhaustible examples in succeeding series, it may be evident that safe and ac-

curate application of any generalization from one of these problem series to another depends upon three conditions or requirements, each of which must be fulfilled, namely: (a) the generalization must be correctly expressed and clearly understood, (b) the situation from whose analysis the generalization was drawn must be known and its relevant elements correctly associated with the generalization and (c) the problematic situation to which the generalization is to be applied must be known in all essential details.

Relatively simple situations like those presented above in our dollar-drawing problems can, in a few hours, be mastered with sufficient thoroughness by an intelligent adolescent to guarantee successful application from problem to problem, provided each generalization be tested in thought and in action before its final acceptance. Some practical problematic situations are sufficiently simple and objective for one individual to master in like degree. But vast numbers of important practical and theoretical problems cross the boundaries of too many diverse fields to permit any one mind or any group of similarly specialized minds to cope adequately with their varied complexities of analysis, generalization and application without further analytical experimentation. And such experimentation often involves the use of concepts and techniques beyond the present grasp of any single individual or group of similarly specialized workers. Here it is that cooperative effort is required among scientists even in the same or neighboring fields. The more remote the field of application is from that of generalization, the greater becomes the difficulty and the danger of error.

That these principles are still recognized and heeded by some scientists and philosophers is evident from recent reports of current attacks no problems and projects of great social import. Thus, in a recent report on Research Problems and Techniques in the Army Air Forces Aviation Psychology Program, Dr. Robert L. Thorndike[11] writes:

"The question of how far psychologists should go in mastering the particular specialty for which they wish to develop measures of proficiency or aptitude is one which raises a broader issue. Fundamentally it is a question of whether personnel psychologists, in addition to a background of experience and highly technical training in appropriate psychological techniques, should also be expected to master the specialties to which they apply these techniques. In general, it may be questioned whether such a philosophy of dual or multiple specialized training will be an efficient utilization of time and effort. The alternative in the Aviation Psychology Program was to draw heavily upon the background and experience of specialists

in the various aircrew jobs. From a practical administrative point of view it was found that the utilization of and inclusion of operating specialists in the development of measuring instruments could result in a more wholehearted acceptance of these instruments by the operating organization. It may well be, therefore, that, in the long run, more practical contributions to the problems of the operating organization will result if the psychologist works essentially as a psychologist in close cooperation with specialized personnel, supplementing systematic observation on his own part by the detailed knowledge of specialists in the field, than if the psychologist attempts first, at the expense of considerable time and effort, to master the specialty and then to proceed in his developmental work in considerable independence of the personnel in the organization which purports to benefit from his services".

In an illuminating discussion of ways and means of understanding foreign cultures and ideologies, Dr. F. S. C. Northrop[7] comments upon the necessity of knowing the basic facts and empirical data from which the generalizations of their ideology spring. He says:

"Properly to understand any culture means not merely to know the basic philosophical premises defining its standpoint but also to be convinced that these philosophical premises are, for the people in question, a reasonable scientific generalization from the empirical data of their limited experience. Never is any culture understood, even when its indigenous ideology is grasped, unless the facts which led to its particular ideology are also ascertained. This means that the philosophy of any specific culture is grounded in its science, even when the people in question may be what we, in the West, have falsely called 'primitive', without science in our more sophisticated form. Any people notes the facts of experience and generalizes from these facts to a philosophy. Consequently, no philosophy of culture is completely understood unless the empirical facts behind the generalizations are also ascertained.

"This means that the present separation of the social sciences and humanities from the natural sciences must be unequivocally repudiated. No humanistic doctrine in any culture is understood unless the underlying philosophy of that culture is understood. No underlying philosophy is sympathetically and emotionally apprehended unless the empirical evidence and process of generalization, essentially scientific in character, taking the people in question from the empirical facts noted by them to their basic philosophy, are also grasped."

Word troubles like those encountered in our dollar-drawing problems are usually experienced in attempting to carry scientific generalizations over to new fields. On this point Dr. Alfred E. Emerson[2] writes:

"If the terms are general enough to incorporate complex phe-

nomena, they are likely to be ambiguous. Nevertheless on occasion fundamental principles may be stated in language that has meaning to most listeners and in a manner that brings orderability to vast accumulations of knowledge. We may thus be emboldened to summarize our main conclusions concerning biological and human relations. (1) Optimal competitive relations survive and too little or too much competition is eliminated through selection. (2) The probability of survival of individual, or groups of, living things increases with the degree with which they harmoniously adjust themselves to each other and to their environment (Leake). (3) A directional trend in evolution is toward a controlled balance of the important factors within the system. Human society cooperatively brings the social environment under control for the better survival of the species.

"If these conclusions are based upon sound evidence and are scientifically valid, we may expect that destructive class, racial, and national war will be largely eliminated. Biology indicates that exploitation of individuals or groups within a population will be superceded by toleration and cooperation."

Perhaps enough has been said about the negative side of our three principles relating to conditions underlying the application of knowledge to new fields by means of appropriate generalizations. This emphasis is in accord with the custom among scientists of ascertaining the degree of accuracy of their measuring instruments and publishing the results in terms of probable errors or standard errors of measurement. This custom is often discouraging to the non-scientist who expects near perfection in the measurements of science only to find that they are often so inaccurate as to reduce our power of forecasting one variable from another to less than one-half the difference between sheer chance and perfect prediction.

Who shall be entrusted with the application of these basic principles to the analysis and interpretation of changes in our social behavior as new industrial processes and improved facilities for communication and transportation plunge us further into the clash of conflicting purposes, ideologies and institutions? Lack of basic knowledge in biology or in social science will almost certainly result in false analysis and over-simplification. Regarding this danger Emerson(2) quotes Liebig as follows: "I have often thought how much pains and how many researches are necessary to probe the depths of a rather complicated phenomenon. The greatest difficulty comes from the fact that we are too much accustomed to attribute to a simple cause that which is the product of several, and the majority of our controversies come from that."

Examples of this fallacy are not hard to find, especially where

attempts are being made to apply concepts and principles of one field into another. How often have you heard the two branches of the Kallikak family compared to prove that intelligence or perhaps character is inherited or is the sole result of environmental influence depending on the point of view of the speaker?

Comparison of the resemblance of identical twins reared together with that of identicals reared apart is supposed to control the factor of heredity and show the effects of differences in environment alone. The fact is that differences apparent before separation may often have been a primary cause of their separation, so that earlier environmental effects from accident or disease may serve as a selective factor in determining which pairs shall be reared together and which apart. This selective factor, if real, certainly introduces a second cause of differences in the degree of resemblance and destroys the validity of any conclusion which is based on the assumption that only one cause is operating.

"Probing the depths of a complicated phenomenon" is an apt characterization of psychologists' efforts to analyze intelligence into its component factors, to work out the interrelationships of these factors, to trace the patterns of their organization and to express these results in objective terms and generalizations for safe and fruitful application to problems of human living. With more penetrating concepts and improved techniques these analyses are still going on and being translated into more effective tests and interpretative procedures. But with all these probings, chiefly among children, adolescents and young adults, no general agreement has yet been attained concerning the average chronological age at which human intelligence reaches full maturity.

Such efforts as have been made to analyze and measure the intelligence of age levels beyond 25 or 30 years have employed the tests, techniques and standards which were specifically adapted for the younger age levels with their recent and fresh acquisitions of attitudes, knowledge and skills relevant to successful taking of such tests and the motivating force of the obvious worth of the test results in their own proper guidance and placement. Such favorable factors are largely absent in the testing of most adults beyond the age of the middle thirties. It is small wonder that these facilities and procedures which failed to bring agreement in the field to which they were thus specifically adapted should be even less successful at the higher age levels to which they were not adapted.

By means of the Army Alpha test Jones and Conrad[5] meas-

ured the intelligence of 1191 residents of 19 villages in rural areas of New England to trace its growth and decline between the ages of 10 and 60 years. Their results showed "a linear growth to about 16 years with a negative acceleration beyond 16 to a peak between the ages of 18 and 21. A decline follows which is much more gradual than the curve of growth, but which by the age of 55 involves a recession to the 14-year level", when the results of all eight of the Alpha tests are taken into account. However, two of these tests "fail to exhibit a post-adolescent decline"; regarding these tests the authors say: "From the point of view of measuring basic or native intelligence, the information tests of Alpha (Tests 4 and 8) present an unfair advantage to the upper brackets." With these two "unfair" tests left out "the recession by age 55 has reached nearly the 13-year level".

In fairness it should be said that these authors were not the only psychologists who as late as 1930 held the view that "basic or native intelligence" could be measured directly by the kind of tests available either then or now.

Regarding the supposed unitary nature of the so-called "basic native ability" measured by Alpha, Dr. Lorge[6] observes: "The Army Alpha measures intelligence and speed in amounts that are undifferentiated. It is not that the Army Alpha measures power intelligence or speed intelligence, but rather that the test reports a score which is a mixture of both."

With Thorndike's C. A. V. D. Intelligence Scale, a test of power having unlimited time allowance, and also with ten other intelligence tests including Army Alpha, Lorge tested a total population of 143 adults ranging in age from 20 to over 70 years. Then in his own words: "In order to evaluate experimentally the rate of decline on speed tests, three groups of age-levels (1) between 20 and 25, (2) between 27.5 and 37.5 and (3) over 40 years were equated person by person on the basis of the C. A. V. D. scale. The three matched groups comprised 23 persons each whose scores on the Army Alpha could be compared." The results of such a comparison showed that the penalty on age for progressive loss of speed in Army Alpha scores was "approximately three-quarters of a point for every year of chronological age beyond 20". After calculating also the penalty placed on age by the Otis test (15 minutes), Lorge observes in commenting on both tests: "The correction for the penalty that a test of mental ability (which is an undifferentiated mixture of power and speed) places upon age, changes the curve of mental

decline to a curve of mental plateau, or even a curve of mental growth."

The analysis of mental abilities and the construction of reliable and valid tests for their measurement is receiving much careful attention, and new techniques and facilities are bringing striking improvements in the construction and use of tests. But little effective effort has yet been devoted to the discovery of tests which are equally valid and reliable throughout the years of adult life and not unduly influenced by sensory and motor deficiencies. Possibly even less attention has been given to the effective control of factors other than intelligence which affect test performance. Surely no test however well constructed will give a true measure of comparative intelligence at different age levels unless all relevant factors other than age are held constant or otherwise effectively controlled in test administration. Even as late as 1938 Cowdry(1) accepted rather uncritically the results of the Jones and Conrad study, maintaining however that: "Many more complex and more specialized tests are needed to reveal the breadth and the limits of the mental powers of age in terms of familiarity and skill and of the possible degree of accumulated and organized knowledge that may tend to hold performance near peak level in the fields of human profession and occupation that are open to more and to less able adults."

It is not easy to estimate to what extent hasty publication of inadequate measurements of intelligence has influenced public opinion and especially that of employers concerning the supposed early decline of mental ability and employability. Certainly any influence that crowds people prematurely out or keeps them out of employment or of training for employment is harmful both to society and to the individuals directly affected. Both economic security and mental health require that the interests and abilities of the people in the later decades of life be discovered and fully utilized.

The importance of building more tests and more suitable ones for the analysis of the mental abilities and of the educability and employability of the older third of our aging population is evident from the growing magnitude of their numbers and from current practices and proposed policies relating to their welfare and their utilization for social ends. Cowdry(1) observes that, "Over one-third of the total population (of United States) will soon be over fifty years of age. In 1980 the number of persons over 65 will be more than double that today." Later he adds: "In 1850 they formed only 2.6 per cent; of the total; fifty years later they formed 4.1 per cent;

in 1930 the figure rose to 5.4 per cent. Thus it is estimated that by 1980, those at the ages of 65 years and over will constitute 14.4 per cent of the total population."

Along with the increasing life span there is a constant narrowing of the range of productive working years. Increasing requirements for general and specialized education consume more and more of the years of early youth and maturity while certain economic policies are increasingly depriving men of work in the years that used to be regarded as the prime of life. Employment counselors are finding that for employment purposes in many fields a man is already considered old at 40 and a girl at 35 years.

Something might be done to restore some of those early adult years to a man's working life by the inauguration of more effective testing, guidance and counseling programs in our schools and by relaxing the lock-step just a little for those exceptional students who have both the desire and the ability to progress more rapidly towards professional or other occupational goals. Space will permit only one citation from one of the more productive research men in this field. Concerning his method in this particular study of 158 women students in college, Pressey(9) says: "The present study attempts, by a systematic comparison of paired cases, to obtain some evidence as to the effects of acceleration in college upon students entering at the same chronological age, having the same initial entering abilities, and attending college at the same time." One item in Pressey's summary and conclusion reads: "The accelerates made the better academic record; further, the more acceleration the better the record was."

That our insistance on a high level of expertness and care in the selection, interpretation and use of tests is not excessive is indicated in a recent review by Flanagan(4) of a book on personnel research and test development. In reviewing the part pertaining to prediction of success in training he says: "This section includes numerous correlation tables comparing scores on classification tests with grades in training schools. In general, the various selection tests were found to yield validity correlations between .40 and .60. In very few instances did information on age, education, or civilian experience add to the effectiveness of the predictions from aptitude test scores.

"The field personnel responsible for classification for training purposes made recommendations in the classification interview which were recorded in four categories. The validity of these recommenda-

tions was studied for a sample of nearly 38,000 trainees. In spite of the fact that the classification interviewers had all of the test scores in front of them at the time they made their recommendations, the validity coefficients obtained for these recommendations were substantially lower than those obtained from the test scores alone. It must be concluded that in this situation interviewing actually detracted from the success of the process, and better results would have been achieved if assignment to a service school had been based on test scores alone.

"After summarizing the results of the various prediction studies the authors conclude that it would be very desirable to have more validation work done using actual performance of assigned duties, rather than course grades."

This citation is intended not as a stricture on the work of properly qualified counselors in the fields of guidance, selection or placement but rather as an indication of the probable inadequacy of as basic training and experience of some of the counselors who participated. The same disparity is found in civilian life today between the number of qualified counselors needed and the number available. Here is another life-sized problem for psychology.

How does the process of applying knowledge gained through psychological tests and correlations to a counseling situation conform to the principle that a generalization can be applied with reasonable safety only by those who grasp it fully and who know the essential features of the situation from which the generalization was drawn as well as the situation into which it is to be applied? The counselor wants to know (1) the test score and its significance in terms of the unit of measurement and the scale in which it is expressed as well as the proved character of the specific items from which it is drawn, (2) the requirements of the situation into which this information is to be applied as expressed in scores of a criterion of known composition and reliability and (3) the correlation between test and criterion scores and how to apply correlation in forecasting.

This exactly parallels the conclusion previously drawn from the dollar-drawing experiment. Here too the certainty with which forecasts can be made depends upon the accuracy and thoroughness with which the three factors are known. In each case it is necessary for someone who knows each of the three factors expertly to participate in the process of selection and application of knowledge to avoid serious errors. Many situations are sufficiently simple to

permit one person to be fully competent in all three phases of the process. Most problems of serious social concern are complex enough to require the participation of several specialists from different fields. In cases which involve serious theoretical or practical consequences it is always wise to subject the proposed solution or application to controlled experimental verification. This spells genuine team-work between persons thoroughly competent in different relevant fields.

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Discoveries In Physical Sciences Having Social Significance*

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The advance in knowledge in the field of physical science has depended to a great extent on the development of scientific apparatus. For thousands of years human beings had to rely on their unaided senses in their attempt to discover the causes of natural phenomena. With such limited and superficial observations, it is no wonder that they arrived at erroneous conclusions; conclusions which, in many cases, had profound influences on the culture of those early periods, and which still influence our culture.

The telescope and the microscope, two of the first pieces of apparatus which were of any practical aid to man's sense of sight, were developed a little more than 300 years ago. The telescope played an important role in correcting erroneous ideas concerning the relation of the earth to the sun and other celestial bodies and in establishing the modern concept of the universe. The microscope played an important role in the development of the cell theory of living things, including the germ theory of disease sanitation. The discoveries made possible by the telescope and the microscope have had far reaching effects on our society.

Rapid Development of Scientific Apparatus

During the past fifty years new forms of scientific apparatus have been developed at an ever increasing rate. By the use of this equipment scientists have been able to accumulate a vast amount of exact scientific information which gives a much better understanding of human beings and their relation to their environment than was previously possible.

The accelerated rate at which scientific knowledge has been acquired during the past few decades is represented graphically in Figure I. In this chart the horizontal dotted line above the heavy unbroken lines represent natural phenomena which were not understood at the time indicated on the base line.

This rapid advance in knowledge has not been limited to any particular phase of natural science but has been rather evenly

*This paper by Professor Hughes was the first of four papers presented at the annual meeting of the Kansas Academy of Science at Pittsburg on April 30, 1948, as part of a symposium "Some Recent Developments in Science with Social Implications." The three remaining papers on the Symposium (by Professors Nagge and Walker and by President Wooster) will be found immediately following Professor Hughes' paper.—The Editor.

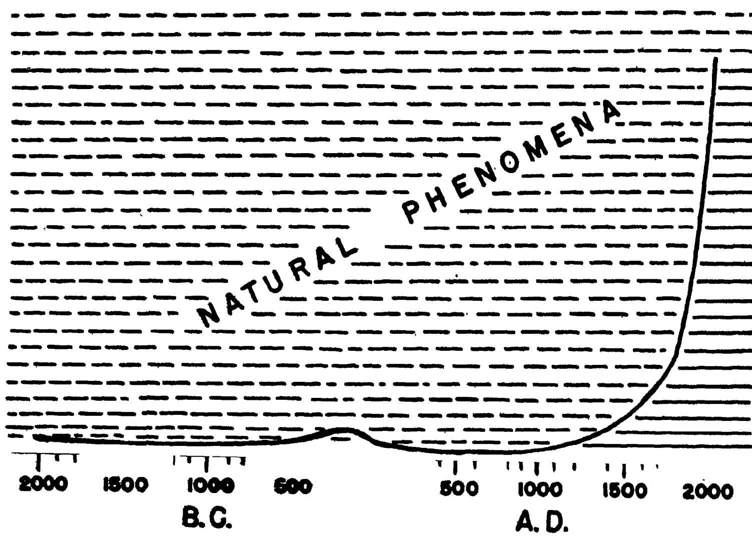

Fig. I. Showing the rapid advance man has made in the last few centuries in understanding natural phenomena.

The horizontal lines are intended to represent natural phenomena of which man is conscious such as changes in climate, weather, reproduction, growth, health, sickness death, etc. The broken lines above the curve indicate phenomena that were not understood at the time indicated on the base line. The solid lines below and to the right of the curve indicate phenomena that was understood. The curve is not intended to be a true quantitative representation of the ratio of the understood and not understood phenomena.

distributed along the entire range from the epoch making discoveries concerning atomic structure to the discoveries of he composition of he very large disease-producing molecules known as viruses.

One important result of these discoveries has been the wiping out of artificial boundaries which men formerly assumed to exist between different segments of science. Knowledge gained in studying the structure of atoms wiped out the boundary between matter and energy. Our ideas concerning the conservation of matter will have to be modified. Whenever chemical reactions which involve energy changes take place, there is also a change in the mass of the reacting system. This change for ordinary reaction is so slight that it cannot be detected by the most delicate balance available. It is only when enormous quantities of energy are involved, as with nuclear fission, that changes in mass becomes apparent. Knowledge gained in the study of viruses has removed the boundary which was supposed to separate the physical and the biological sciences, concerned respectively with living and nonliving matter. Today's

program was set up on the assumption, still widely made, that such a boundary exists.

Nature has no boundaries separating various types of substances. There is a gradual change from the simplest to the most complex forms of matter. Figure II is intended to represent in graphic form this unity of science. The question mark at the left indicates the

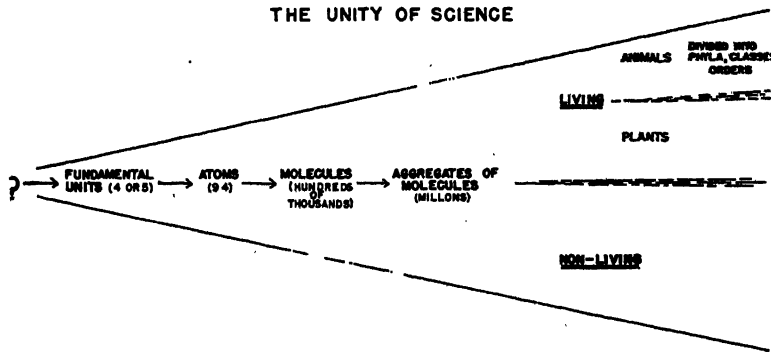

Fig. II. This chart is intended to show that there is no sharp boundary between the physical and the biological sciences. A knowledge of the fundamental units, atoms and molecules, is just as important to the study of the living cell as it is in the study of non-living matter.

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area of natural phenomena which cannot be adequately explored with our present scientific apparatus.

We will now consider some of the more important experiments in each of the types of matter, beginning with the simplest form, the fundamental units, and then progressing through the more complex forms, namely, the atoms, the smaller molecules, the larger molecules, the unicellular organisms, plants and animals, and then the organization of human beings in society.

The Fundamental Units

The so-called fundamental units which nature uses to build atoms are the simplest substances that can be studied by present day scientific methods. While little or nothing is known about their nature, enough has been discovered concerning the properties of four of these units (photons, electrons, protons, and neutrons) so they may be put to practical uses.

The photon, a unit of radiant energy, of which light is the commonest form, has neither mass nor electric charge. Knowledge gained by research concerning the generation and detection of radiant energy has made possible radio, radar, modern illumination, motion pictures, ultra violet ray and X-ray for both industrial

and medical use. It is impossible to estimate the influence on society of the practical application of scientific information concerning radiant energy.

The electron, the second of these fundamental units, possesses both electrical charge and mass. It is known to possess electric charge because of its behavior in both the electro-static and the electro-magnetic field. It is known to have mass from the fact that it requires force for acceleration. Moving electrons, which constitute electric current, produce magnetic fields while a changing magnetic field causes electrons to move. The practical application of the properties of electrons is the basis of the entire electrical industry, including the telephone and the telegraph. Oscillating electrons produce radiant energy. It is through the oscillation of electrons at different frequencies by appropriate mechanisms that all the various wave lengths of radiant energy are produced.

It is known now that oxidation with its production of heat is a chemical reaction in which electrons shift from atom to atom. This shifting of electrons is the source of all the energy of living cells. In the last decade remarkable advances have been made in our knowledge of these energy producing reactions in the animal body. Shifting of electrons in chemical reaction is the source of most of our industrial power. The per capita quantity of power available for industrial use is one measure of the material standard of living of a society.

A recent development resulting from our knowledge of the property of electrons is the electron microscope. In this apparatus a stream of electrons replaces the ray of light and magnetic fields replace the lenses of the ordinary microscopes.

With this new apparatus it is possible to photograph particles as small as one-hundreth the size of the smallest particles that can be seen by the most powerful compound microscope. This procedure makes it possible to study directly the sizes and shapes of the smallest known viruses.

Another new type of apparatus which makes use of the electron is the betatron, so named because the beta rays eminating from radio-active atoms are electrons. The betatron is a mammoth magnetic slingshot which can accelerate the velocity of electrons to a speed approaching the velocity of light. It is hoped that information concerning the nature of fundamental units and atomic nuclei may be secured by observing the reaction which occurs when these high velocity electrons are shot into atoms.

The proton, the third fundamental unit, carries a positive charge of electricity and possesses 1800 times the mass of the electron. This particle of matter, called by the physicists a proton, is called a hydrogen ion by the chemist.* It is a hydrogen atom minus its orbital electron.

The development of a means of measuring and controlling the hydrogen ion concentration of a solution has played an important part in many industrial and agricultural processes.

Living cells are highly sensitive to hydrogen ion concentration. Of the many automatic controls of chemical processes in the body, none is more elaborate or more complicated than the automatic control of the hydrogen ion concentration of body fluids and tissues. Some idea of the importance of this control of hydrogen ion concentration can be gained from the fact that one-half of a drop of normal gastric juice contains enough hydrogen ions to kill a person if they were allowed to spread through the body without being neutralized by this marvelous automatic control.

A cyclotron, popularly known as the atom smasher, is used to increase the velocity of protons and other particles carrying positive charge in the same manner as betatron is used to speed up electrons. The cyclotron has been one of the key pieces of equipment used in the study of atomic structures. The mammoth cyclotron at the University of California has accelerated alpha particle (the nucleus of the element, helium, which has about four times the mass and twice the charge of protons) to a speed imparting to it 400,000,000 electron volts. When these high velocity alpha particles are shot against a few uranium atoms, the nucleus of these uranium atoms is shattered, yielding a large number of nuclear particles, among which about 60 elements have been identified. These include practically all the elements with atomic number greater than iron, the atomic number of which is 32.

Discoveries made possible as a result of the development of the cyclotron and betatron have had untold influence on society.

The neutron, the fourth of these fundamental units, has about the same mass as the proton but possesses no charge. It cannot be accelerated and directed as can charged particles. The only source of this important fundamental unit is decomposing atomic nucleus. Knowledge concerning the properties of neutrons is an

*It should be noted, of course, that the hydrogen ion in solution is undoubtedly more complex, because of hydration, than the proton of the physicist.

important factor in the production of the atomic bomb and atomic energy.

Organization of Fundamental Units into Atoms

Atoms are the simplest form of matter made through the organization of fundamental units. They are characterized by a single nucleus carrying one or more units of positive electricity surrounded by an equal number of electrons.

Centuries ago alchemists dreamed of transmuting base elements, such as sulphur, to noble elements, such as gold. The alchemists possessed neither the understanding of the structure of atoms nor the equipment necessary to make such a transformation. During the past few years physicists and chemists have acquired sufficient information and have developed the necessary apparatus to accomplish this dream of the alchemists. Four new elements with atomic number 93, 94, 95 and 96 and more than 500 new atoms having the atomic numbers of elements found in nature have been made. The discoveries which may be used for the production of enormous quantities of energy through nuclear fission, rank among the most momentous discoveries ever made. The importance of these discoveries has been thoroughly discussed in the popular press.

There is one effect which these discoveries have had on our society but which has received little attention. Government officials, both legislative and administrative, have decided that future research and development in this field of atomic energy is potentially too dangerous to be entrusted to free competition and individual initiative, the system that has served us so well in the past. Accordingly, the Atomic Energy Commission has been credited. It has absolute authority over all such research and development. This first step in the direction of government control of scientific research may have far-reaching effects.

Organization of Atoms Into Molecules

Just as the fundamental units, because of their properties, arrange themselves into groups called atoms, so atoms, because of their properties, arrange themselves into groups called molecules. If all the atoms in the group have the same atomic number, the substance is an element; if they have different atomic numbers the substance is a compound.

Thousands of such compounds occur in nature. Until about 100 years ago these compounds were divided into what were thought to be two distinct classes: those occurring in living organisms and those occurring in lifeless things. According to the then almost

universally accepted vitalistic theory, compounds occurring in organisms, called organic compounds, were thought to require a vital force for their production. In 1928 a typical organic compound, urea, was synthesized in the chemistry laboratory. This substance was first of a long series of experimental results that have shown the fallacy of the assumption of a special vital force necessary for producing organic molecules or for organizing molecules into living cells.

Industrial Uses of Properties of Atoms

During the last few decades enough has been learned about the properties of atoms, the forces which hold them together in compounds and the properties which certain groupings of the atoms impart to compounds, that industrial chemists can make a compound having almost any property that industry wants. The names of a few of such compounds in every household will suffice to show how these compounds have entered into everyday living: rayon, nylon, rubber, dyes, perfumes, soaps, water proofing compound, many kinds of plastics, paint pigments, as well as many kinds of alloys with special properties.

As interesting and important as these compounds are, (they have made possible the production of hundreds of useful substances) the synthetic compounds which are used in foods and medicines are of still more interest and importance. In this group of compounds we have vitamins, hormones, anesthetics, antibiotics and dozens of important drugs. The use of these compounds has resulted in a marked increase in the effectiveness of both preventive and curative medicine. This improvement in medical practice has helped to increase average life expectancy in the United States from 40 years to 60 years or more. The resulting shiftings in age groups in our population has important social implications.

Just as improved apparatus has enabled physicists to push forward the frontier of their science in the direction of smaller practicles of matter, so the development of new apparatus has enabled the chemist to push the frontier of chemistry in the direction of larger and more complex molecules and aggregations of molecules until now this frontier of chemistry has overlapped the frontier of microbiology.

Understanding the Nucleoproteins

The most interesting compounds in this field that are common to both chemistry and bacteriology are the viruses. About 50 years ago the bacteriologists discovered the first of these mysterious

disease-producing agents, which are responsible for such diseases as yellow fever, poliomyelitis, virus pneumonia, mumps, influenza, and measles. These viruses are too small to be seen by the use of the compound microscope. Although real progress was made in methods of developing immunity against some of those diseases, no progress was made by bacteriologists in learning the true nature of these mysterious agents until just 12 years ago, when a chemist isolated, purified and crystalized the first of these compounds which the bacteriologist had considered to be living cells. Figure III shows an electron microscope picture of some of these interesting compounds.

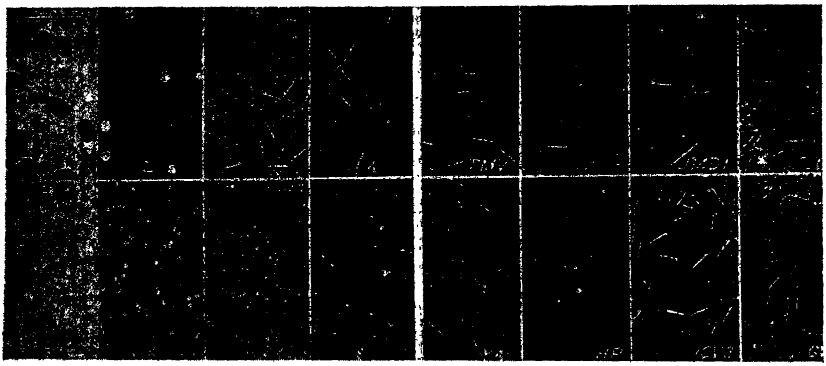

Fig. III. Left (numbered photos). Electron micrographs of purified virus preparations. 1. Vaccinia virus. 2. Influenza virus (Lee strain). 3. Tobacco mosaic virus prepared from hair cells. 4. Potato X virus (latent mosaic of potato) hair cell preparation. 5. T: coil bacteriophage. 6. Shope rabbit papilloma virus. 7. Southern bean mosaic virus. 8. Tomato bushy stunt virus magnified 19,000 times. Fig. IV. Right (lettered photos). Eight strains of tobacco mosaic virus. Preparations made from hair cells and shadowed with gold. Magnified 16,000 times. From W. M. Stanley in Chemical and Engineering News, 1947.

The study of these large disease producing molecules has bridged the gap between chemistry and bacteriology and has shed a flood of light on the mystery of living cells.

These compounds proved to be nucleoproteins of very high molecular weight. These nucleoproteins that function as viruses when introduced into proper living cell have the property of self-duplication. This unique property may be the key to the understanding of the mystery of self-duplication of living cells. Chromogenes which genetists have found to control inheritance are composed of self-duplicating nucleoproteins.

It now seems that these nucleoproteins may be classified into three groups according to their mode of action in cells. The first

group is found in the nuclei of the cells of plants and animals. It seems that all of the molecules of nucleoprotein in one nucleus are associated in some way so that when one duplicates itself all the others duplicate themselves. The cell then divides and the daughter cell is a replica of all the molecules of the nuclei of the parent cell. Since these molecules, which are probably the units called genes, control the properties of the cells, the daughter cell is just like the parent cell.

The second group of genes are those occurring in the cytoplasm, that is they are outside of the nuclei. These genes, called plasma genes, do not all self-duplicate at the same time. This behavior is in marked contrast to those in the nuclei, which all duplicate in unison. For this reason the plasma genes in the daughter cells are not always similar to the plasma genes in the parent cell, a behavior which is probably the explanation of the differentiation of cells into various tissues.

The viruses, the third group, may be called gypsy genes for they do not remain in the cells where they reproduce themselves, but spread throughout the body fluids. They may find their way by any one of a number of means into other individuals where they may again self-duplicate. In this way, virus diseases may spread rapidly through a community. Information concerning these viruses has been accumulated at an increasingly rapid rate since a chemist made a start by crystallizing one 12 years ago. It has been shown by chemical analysis that the difference in strains of virus which produce different symptoms in tobacco plants, are due to slight differences in their composition. Virus, the gypsy gene, can self-duplicate or reproduce only in living cells. It may be possible sometime in the future for chemists to make viruses to order as they now can make many simpler compounds. Viruses no doubt will play an important part in any possible bacteriological warfare.

Organization of Molecules Into Aggregates Including Living Cells

Just as fundamental units, under favorable conditions, organize themselves into atoms and these atoms, under favorable conditions, organize themselves into molecules, so these molecules organize themselves into aggregates. Thousands of such aggregates are found in nature and chemists have synthesized thousands of additional ones. Owing to the shortness of time set for this discussion, only those aggregates containing self-duplicating nucleoproteins will be considered. Such aggregates are known as living cells. Just as knowledge gained by physicists concerning the structure and prop-

erty of atoms has made it possible for the chemist to understand molecules which are composed of atoms, so the knowledge of the structure and property of molecules has made it possible for biologists better to understand the living cell. It should be pointed out that before a chemist can really understand his field, he must first acquire knowledge in the field of physics. In the same way a microbiologist who would really understand his field must first understand the field of chemistry. Three of the discoveries made by chemists concerning the properties of molecules have played an important role in solving the mystery of the living cell. In 1916 it was discovered that if molecules were constructed in such a manner that one end was soluble in water while the other end was not, such molecules when placed on the surface of water would orient themselves so that the water soluble end would be down in the water while the other end would be standing up out of the water. This simple discovery gave the clue to the forces which orient the molecules in living cells which are responsible for the cellular property of irritability.

Living cells are of such a shape and so minute in size that they have great surface area compared to their volume. By placing certain compounds on the surface of a cell it is possible to alter the orientation and thus alter the property of the cell. One practical application of this fact is found in the use of anesthetics. These so alter the orientation of the molecules of the nerves that they no longer can convey a nerve impulse. Other compounds will bring about just the opposite result. Incidentally, the discoveries in this field of orientation of molecules in surfaces has made possible all the new suds producing soaps, as well as the compounds for water proofing fabrics.

The second discovery came in 1926 when an enzyme was purified and crystallized. This process of isolation proved beyond question that enzymes, which bring about reactions in living cells are large protein molecules. The discovery of how to prepare these pure crystaline enzymes paved the way for the rapid advance in our knowledge concerning the enzymes, knowledge which solved the mystery of how living cells bring about chemical reactions. Such reactions provide the cells with the compounds necessary for reproduction and for energy needed to carry on the cell activities. These crystaline enzymes can be dissolved in water and will carry out in a test tube the reactions they normally carry out in the living cell.

The third important discovery (1936) was the isolation, purifi-

cation, and crystallyzation of a self-duplicating nucleoprotein. These nucleoproteins or viruses, discussed above, may be the key to the mystery of cell multiplication.

Chemists have taken living cells apart and so learned of what they are made. As yet, chemists do not have the skill or the apparatus necessary to put these pieces together again. They are, perhaps, as near to putting them together again as physicists were to putting pieces of atoms together to make new atoms fifty years ago. These discoveries about the true nature of the living cell will have far reaching effects on some of the basic philosophies of living.

Organization of Living Cell Into Human Beings

Just as molecules under suitable conditions will arrange themselves into living cells, so living cells under suitable conditions will arrange themselves into organizations ranging in complexity from the simple chain of bacteria to the complex human body. In no field of science has the advance in knowledge been greater during the past three decades than in that relating to the factors which regulate and synchronize the activities of all the various tissues of the body into a harmonious whole. This knowledge solves much of the age old mystery of the nature of men.

Among the illuminating discoveries in the field of physiological chemistry is that of vitamins and hormones and of the profound effect these compounds have on the personality and behavior of human beings.

Discoveries Concerning Vitamins

The vitamins are organic compounds which, together with enzymes, are necessary for bringing about chemical reactions in living cells. Most microorganisms and plants can make their own vitamins. Animals, including human beings, do not possess the ability to make these compounds, so they must secure them from their food. The word vitamin was coined in 1912 to designate this important class of compounds. It required twenty years of intensive work by many research workers before the first vitamin, vitamin C, was isolated and synthesized. Since then remarkably rapid progress has been made in this field, resulting in the discovery and synthesis of fourteen more of these compounds. Experimental evidence indicates that there are probably only three or four more to be isolated. Most of these 15 compounds can be produced in the laboratory so economically that they compete in price with the natural products. In some cases the synthetic ones are much cheaper. In

composition and function these synthetic compounds are identical with the natural vitamins and the natural ones are identical whether they are secured from micro-organisms or plant or animal tissue. This identity is but one of many facts that show the close similarity of all living cells.

Deficiency diseases such as rickets, scurvy, digestive disturbances, night blindness, pellagra, beri-beri, and anemia result from an inedequate quantity of vitamins in the food. The clinical symptoms displayed by an individual who has an inadequacy of one or more of the vitamins will depend on the tissue affected most. The effect on the nervous system of the lack of thiamine will show what profound affects an inadequacy of one of the vitamins can have on human personality. Dr. Wilder[1] of the Mayo Clinic describes as follows the effect on a group of individuals who received an otherwise adequate diet low in thiamine for a few months:

"It should be emphasized that these disturbances were unmistakable and easily demonstrated changes of personality, reflected in attitudes and behavior. All the subjects became irritable, depressed, quarrelsome, un-cooperative and fearful. Without knowing why, they thought that some calamity awaited them. Two became agitated, thought that life was no longer worth living, and threatened suicide. All became inefficient in their work because of generalized weakness, inability to concentrate, confusion of thoughts and uncertainty of memory. There was loss of manual dexterity. There were frequent minor accidents and much breaking of equipment. Those women who engaged in sewing or knitting became inaccurate, dropped their needles, and could not thread their needles. Those assisting in the kitchen and laboratory with dish-washing broke the glassware." These abnormalities disappeared when an adequate quantity of thiamine was introduced into the diet without the knowledge of those undergoing the test.

It was just ten years ago that the lack of niacin was discovered to be the cause of pellagra. One of the symptoms of this deficiency disease is a peciliar type of insanity. It is known that hundreds of people were confined in insane asylums just because their food was deficient in this simple organic compound.

Not a tissue in our body can function normally unless it receives an adequate quantity of the vitamins it needs. With an inadequacy of vitamins, as well as of other nutrients, physical

(1) Russell M. Wilder, M.D. Symptoms and Signs of Thiamine Deficiency. Rec. Publ. Ass. nerv. ment. Dis., 1943, 22: 101-112.

power will be reduced through the failure of the muscles to function normally. Mental power will be reduced through the failure of the central nervous system to function normally and spiritual power will be reduced through the failure of the involuntary nervous system and ductless glands to function normally. The importance of these facts in human society is apparent from the fact that careful surveys by the Federal government have shown that a majority of the people in the United States do not receive an adequate diet. Enough is now known about foods and nutritional requirements so that it is no longer necessary to guess whether or not we are getting an adequate diet.

The Importance of Hormones

Paralleling these important discoveries concerning vitamins were the equally important discoveries concerning hormones. These compounds, unlike the vitamins, are made in the animal body. Their function, together with the involuntary nervous system, is to regulate and syncronize the activities of all the different tissues of the body into a harmonious whole. Every one of our vital functions, such as digestion, blood pressure, temperature, composition of the blood, providing extra energy in emergency, all phases of reproduction, are under the automatic control of the hormones and the involuntary nervous system.

One of the most significant discoveries made concerning human behavior is that the compounds responsible for these automatic controls in the human beings are identical with the corresponding compounds in all the lower animals. Hormones derived from animals are now extensively used in human medicine.

Two examples will be sufficient to show to what extent hormones influence personality and behavior. All differences in the structure of the body and the behavior of male and female are due to the male and female hormones. By the use of female hormones, a single organic compound that can be made in the laboratory, the mammary gland can be developed in the male and caused to produce milk. Maternal behavior can be developed in either male or female experimental animals by the injection of a hormone produced by the pituitary gland which controls the so-called maternal instinct in reproduction. It is interesting that the poultry where the development of the brooder makes maternal behavior unnecessary, the production of this hormone has been so reduced through selection in a certain strain of hens, that they will no longer develop enough broodiness to set on eggs. It is not uncommon for females

to be masculinized through the abnormal production of the male hormone in their bodies, especially when the ovaries decrease the production of the female hormone.

If the thyroid in a child fails for any reason to produce its hormone, thyroxine, the child develops cretinism, a condition characterized by a failure of the central nervous system to develop so that the child retains the intelligence of an infant. The body does not develop normally, resulting in a cretinous dwarf.

The Nerves and Chemistry

Another phase of physiological chemistry which has received intensive study during the past few years is the chemistry of the nervous system. Of the many important discoveries which have been made in this field only two will be mentioned: one concerning the mechanism by which the nerve impulse influences the cells controlled by the nerve and the other concerning compounds which influence irritability of the nerves.

It has been found that the nerve impulse sets free a chemical compound at the nerve ending. This compound then causes a response in the Cells involved in much the same manner as hormones influence cell activity. In the sense that the nervous system is a specialized ductless gland, instead of producing its hormone at one place and having it carried to all parts of the body by the blood, it is branched out to all parts of the body and produces its hormone where it will react on only the cells concerned. In this way one muscle or gland can be made to react without involving all the others. There seem to be two of these nerve hormones, one acetylcholine, and the other, adrenaline or an adrenaline-like compound. In the heart, the parasympathetic fibers liberate acetylcholine which acts as a brake on the heart while the sympathetic fibers liberate an adrenalin-like compound which accelerates it. The peripheral motor nerve fibers liberate acetylcholine which causes the muscle fiber to contract. From this it will be seen that acetylcholine which slows down heart muscles causes the contraction of voluntary muscles. This result is much like the selective action of adrenalin on various tissues.

As soon as the liberated acetylcholine has completed its function it is split into two parts, choline and acetic acid, by an enzyme known as cholinesterase. This action renders it inactive. Another enzyme system builds it back into the cells at the nerve ending so it can be liberated by another nerve impulse. These enzymes which

build and split acetylcholine have been isolated and the reactions carried out in a test tube.

A compound, di-iodoisoprophyl flurophosphate, which completely inhibites the action of cholenosterase has received considerable study with the view of its use in chemical warfare. When an animal, or a human being, is exposed to this compound, acetylcholine liberated by the nerve impulse accumulates in the body not only in muscles and glands but also at synopses in the brain. This accumulation of acetylcholine brings about violent reactions.

Chemical analysis of the nervous system, including the brain, shows it to be a delicately balanced organization about one-third of which on a dry basis consists of complex fat-like molecules. When a nerve impulse moves along a nerve fiber there is an electrical potential set-up between the small segment of the nerve where the chemical reaction is going on and the portion of the fiber in front of the moving impulse. This electrical potential causes a current of electricity, which consists of movement of ions, to flow between these two points on the fiber. This phenemenon is known as the action current, and is an integral part of the nerve impulse and is probably a key factor in causing the impulse to advance along the fiber.

The degree of irritability of the nerves seems to be related to the resistance offered to the flow of this action current. If a chemical compound is put on the nerve which alters its organization so that the fat-like molecules tend to become continuous and the other molecules more dispersed, the resistance to the action current will be increased. This effect would reduce irritability. If this shift in organization is carried far enough to stop the action current, the nerve impulse would be blocked. Compounds which tend to make the water portion of the nerve continuous and the fat-like molecules discontinuous, would reduce the resistance to the action current. This would result in an increase in irritability of the nerves.

This change of phase from oil-in-water to water-in-oil emulsion can be brought about in a water and oil emulsion in a test tube by many of the compounds that influence the irritability of nerves. Dozens of such compounds are now being used in the practice of medicine to regulate nerve irritability.

If the nerves are rendered too irritable the person loses will power and has involuntary muscular contractions or spasms. If irritability is lowered to a sufficient extent, will power is lost and the individual goes into a coma.

That portion of the nervous system concerned with mental ability is the most sensitive to the action of compounds which influence irritability.

These briefly mentioned discoveries in the field of physiological chemistry are but a few of many such discoveries, all of which show that these functions of all the tissues of the body depend on their chemical composition and the chemical reactions going on within them.

It has been my privilege for a number of years to teach classes in physiological chemistry, including a course in the chemistry of vitamins and another one in the chemistry of hormones. I have also had the opportunity to speak at many farm meetings concerning these compounds. It has been my experience that people are eager for information concerning the compounds which help them understand why they look and act as they do. In my opinion, change in thought resulting from these discoveries concerning the physical basis for abundant living will bring about greater changes in society in the future than the discoveries in the field of atomic energy.

Organization of Human Beings into Society

The human being is the unit in the organization of society just as the living cell is the unit in an organized human body. The lag in our social development in comparison to our industrial development may be due in part to the failure of leaders in various social institutions to study the human being as thoroughly as the physical scientists study the units which make up the organization with which he works.

If our nation is to remain strong, some means must be found to put into practical use in the training of our youth the discoveries which have been made concerning the physical basis for abundant living.

Some Recent Biological Developments With Social Implications

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"Why does not the gastric juice digest the walls of the stomach?" is a question, the answer to which has baffled physiologists all through the years. The most common answer, namely, that the thing we call "life" prevents such digestion, and that when "life" disappears then the enzymes of the gastric juice *will* act on the stomach tissues, is an answer, but not an explanation.

But in any case that question and that answer illustrate a problem which has long puzzled biologists; and one on which progress is slowly being made. Whatever progress is being made certainly bears important social implications for mankind.

The questions which mankind has asked through the centuries are briefly as follows: What *is* life? What can it do? How does it resist attack from enzymes, from insects, from disease and from the various forms of parasites and saprophytes to which it is subject? And finally, how can that resistance be increased or supplemented by the things which we living beings do or do not do?

It is this last question which we have selected to form the focal point of our discussion in our part of this symposium.

The sort of thing which we propose to discuss may be further indicated by such terms as vitality, vigor, immunity, resistance to disease. It involves such questions as: What constitutes vigor and vitality? How are they attained or increased? What are the factors which produce immunity or resistance to attack? What do nutrition, vitamins, disinfection, medicines, et cetera, have to do with it?

The answers to these questions are partly physiological and partly ecological. When we speak of "ecological" we are thinking of the fact that the welfare of an organism is partly the product of its environment, including other organisms. The interrelations of organisms are sometimes harmful and sometimes beneficial. Considerable progress has been made in recent years by experiment and experience along physiological-ecological lines. It is by means of a description of a few of these experiments and experiences that we wish to illustrate recent biological progress in matters having important social implications.

For the sake of illustration we shall first draw upon two or three recent significant experiments performed under the direction

of Dr. William A. Albrecht, head of the department of soils, College of Agriculture, University of Missouri. These experiments have to do with the nutrition of plants and the effect of that nutrition on resistance to attack by other organisms.

Using pure, sterilized, quartz sand as a base, Dr. Albrecht added increasing amounts of calcium fertilizer to successive pots and started plants therein. The more nearly normal the amount of fertilizer, the more vigorous was the growth of the plants. The plants in these pots were attacked by a fungus, but the more vigorous the plants, the less the effect of the attack. The most vigorous of the plants showed slight effect of the fungus.

This result is an interesting and valuable demonstration of a fact already well known, namely, that low vitality, from whatever cause, subjects the organism to more effective attack by other organisms. Cases are not uncommon among human beings in which a fungus growth, such as "athlete's foot" has covered large areas of the body when the body-vitality was greatly reduced because of poor nutrition, debilitating drugs, or other causes.

In another experiment Dr. Albrecht planted spinach in horizontal and vertical rows with increasing amounts of nitrogen in the successive verticle rows and increasing amounts of calcium in successive horizontal rows from the bottom upward. The spinach plants were attacked by insects (thrips). The attack was progressively less severe from the less vigorous to the more vigorous plants.

We quote from Dr. Albrecht's report: "These two nutriants, nitrogen and calcium, are helpful in protein synthesis by the plants, and suggest that protein is protection for the plant against insects, as it is also protection against disease in human beings."

Dr. Albrecht fed rabbits on lespedeza hay grown on different soil types to demonstrate the familiar fact that nutrition does make a difference in growth, development and vigor of organisms. The rabbits which were fed on the hay grown on less nutritious soils of course showed deficient growth in bones, muscles and other tissues.

Dr. Albrecht performed these experiments to demonstrate the fact that nutrition does make a difference. As he says: "to be well fed is to be healthy."

It might be here reported that experiments are now under way, making studies of the mineral content of wheat grown on different soils in different parts of the country and the effect of that wheat on the nutrition of animals, including human beings. The effect of

nutrition, including minerals and vitamins on teeth, bones, muscular and nervous vigor is a tremendously important matter to human welfare.

We hardly need to call attention to the fact that there are many parts of the world at the present time where the social impact of these matters of nutrition and disease is terrific.

There are other aspects of the matter of vigor and immunity which we hardly have time to discuss. For example, there are the facts we are learning about the value of struggle for existence in the production of immunity. There came to our attention recently the case of a bacteriologist, who, when a baby arrived in his household, proceeded to see that everything with which the baby came in contact was thoroughly sterilized, clothing, bedding, bed, bottles, and later toys, floor, furniture, everything. And of course the baby's body had no opportunity to build up a resistance against the common, everyday ubiquitous germs against the inevitable day of contact with them, and with disastrous consequences.

All of which leads us to call attention to recent developments in vaccines and serums, the main principle of which is to insert germs into the system in weakened, but sufficiently potent form, to cause the body to fight them and thus build up resistance, and even immunity to them. This is one example of a situation in which an enemy may be turned into good friend.

A recent development of somewhat different kind has come to my attention. Dr. Edward A. Doisy, biochemist at St. Louis University, and his helpers not very long ago isolated, and then synthesized vitamin K, which, "in some manner, not yet too well understood, stops bleeding." According to one report this vitamin has already "saved the lives of tens of thousands of newborn babies that otherwise would have died of hemorrhagic disease."

Vitamin K is used in connection with certain surgical operations, and has become a first-hand aid to the obstetrician. But of still more interest, if not importance, to the biologist and ecologist is the way in which Vitamin K is produced in the body. It seems to be a "by-product of the bacterial life which thrives in the intestines." Normal adults, therefore, usually have all of this vitamin which they need. But adults with certain obstructions do not, and new born infants do not yet have this intestinal flora—at least not from the second-to-the-fifth day after birth. "During that second-to-fifth-day-period infants have a tendency to bleed from minor wounds and from the umbilical cord. More serious, they often bleed into the

skull to cause death." Vitamin K has been and will be a life-saver to thousands annually.

What is vigor and what is vitality? We do not know, but this we do know—that they are the manifestations of the thing we call LIFE, plus the help of other factors, and that *LIFE has marvelous powers and abilities.* We also know that the more the biologist can find out for us about life, its nature and its powers, the better off we shall be . In other words, the more of truth the scientist finds the greater the freedom man attains. Biological developments do indeed have social implications for the welfare of mankind.

Scientific Developments in Psychology With Implications For Social Change

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It has been written somewhere that psychology has a short history but a long past. This is a pithy way of saying that people have had a pressing interest in the study of their own psychological reactions and those of other people long before a respectable fund of scientific knowledge was available for their guidance. Primitive man felt a need for more knowledge of the mainsprings of psychological reaction in other people because he had to deal with those other people in his everyday living and his success or failure in promoting successful personal relationships with other people was closely associated with his own personal happiness. He soon discovered that many of his problems resolved themselves into those of personal relations with other people.

In the past seventy-five years, which period encompasses the history of experimental psychology, most of the work accomplished has been aimed at putting the psychological house in order, mapping out the fields of psychology, developing methods of procedure and doing the basic housekeeping tasks before attacking the problems of applied psychology the solution of which was of such importance before the practical problems of everyday life could be worked upon. Much of the early work fell into the category of "pure science." There was little done in that period in the field of applied psychology because applied psychology involved a discussion of "value" and value was a category of philosophy from which psychology like the other sciences had struggled for emancipation for so many centuries. With accumulated knowledge and with the assurance of a discipline approaching maturity, psychology is now fully ready to plunge into the fields in which 'value' is a category. This involves asking the question, "what is the utility of the results of this psychological experiment?" An undue emphasis upon *value* in science can be a danger to the growth of *pure science*. Fernberger has aptly stated in a recent article in the *American Psychologist* that pure science might tend to be neglected and we might thus "kill the goose that laid the golden eggs."

Knowingly or not, all science tends to change its patterns to meet human needs. Pressing problems in psychiatry, in industry, in

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the classroom, in medicine, in vocational counseling, in war, in social relations, in personal maladjustment, in old age, and in other areas have given a strong impetus to the development of our psychological studies in these fields. Commerce follows the flag and psychological research follows appeals for help from related fields of work and interest.

The contributions made by psychological workers in both World Wars I and II are potent examples of this. So great was the demand for psychologically trained help that the supply never approached the demands for such services from the Armed Forces. In the recent war they worked in the areas of the classification and assignment of personnel, in that of the selection and training of air crewmen, in that of clinical psychology, in that of personal counseling, in that of the development of more effective armaments, in that of psychological warfare, etc.

A tabulation of the classification of research papers in psychology and closely related fields as they appeared in *Psychological Abstracts* for the years 1946 and 1947 reveals significant data. Of about 9600 titles abstracted during this period those classified under *functional disorders* amounted to about 14% of the total; those under general *social processes* about 11%; those classified under *industrial and personnel problems* about 9%; educational psychology about 10%. The balance or 56% fell into other categories. The given percentages are a reflection upon the preoccupation of a large group of psychological workers with problems of a practical nature having social significance.

Returning to two of the major categories listed above from the *Psychological Abstracts* namely that of *Functional Disorders* and that of *Industrial and Personnel Problems* we can mention some trends of development. Samples from additional fields also will be offered.

Functional Disorders: The functional mental disorders constitute about 95% of the cases of mental disease in this country. The psychoses or the true insanities constitute the remaining 5%. There are divergent opinions regarding whether or not the number of cases of mental disease is increasing in this country. Be that, as it may, we are certain that mental disease is now increasingly recognized as a psychological and sociological problem of vast extent. The whole subject of psychosomatic medicine has come into its own in the last five years with the recognition that the physician must also know some psychiatry in order to understand many of the physical

symptoms which patients bring to him. An appreciation of the rôle of emotional factors in the etiology of physical complaints constitutes psychosomatic medicine. New methods of treating the psychoses with electric shock, lobotomy, etc., are promising to be of some help in the alleviation of these conditions. Newer methods of treatment of the psychoneuroses include such drugs as sodium pentothol and sodium amytal which permit a more complete emotional purging of the subject. Insulin shock therapy has also been applied in the treatment of the psychoneuroses. In the treatment of epilepsy the drug, tridione, seems to be of great promise in eliminating or alleviating epileptic seizures particularly of petit mal.

Music therapy, occupational therapy, the psychodrama where a patient acts out his emotional conflicts, directive and non-directive counseling techniques are also devices used in the treatment of psychoneurotic conditions.

Any psychological techniques which tend to alleviate the social consequences of mental disease are obviously developments of some importance. A consideration of the economic loss to society as well as the loss of personal happiness in the case of the sufferer from mental disease is apparent and any treatment aimed at shortening the period of convalesence or in preventing the re-occurence of such disease has a social significance of importance. I believe that today we are on the threshold of even greater discoveries in the matter of treatment in the field of mental disease.

Industrial and Personnel Problems: It has been increasingly apparent in recent years that the personal satisfaction and pride of the worker in his job is an important variable in social well-being. This well-being is reflected in greater output of work and in greater personal happiness. The psychological problems of industry and personnel are the problems of individual differences among people. How may individuals with different aptitudes and abilities be best fitted to various types of occupations? In any one occupation the most productive workers are probably two or three times as productive as the least productive. Aptitudes are inferred from such differences between individual workers in acquiring proficiency in a given task. The field of vocational counseling has had an important enlargement of interest directed at it in recent years. Tests of various aptitudes and abilities have been developed as measuring instruments. Prior to their formulations the psychologist makes an analysis in detail of the psychological processes required in the successful performance of the work. After suitable tests are chosen or newly

devised for the measurement of the traits in question we have an aptitude or an ability test. Intellectual, personality, vocational interest and motor aptitudes and abilities are all taken into account in the fitting of round pegs into round holes. After finding suitable employment the worker still has personal problems which affect his efficiency such as financial worries, domestic difficulties, fear of loss of employment, etc. Being cognizant of the deleterious effects of such problems on the worker some industrial firms employ counselors, psychiatrists, and social workers in order to alleviate the emotional strains which adversely affect worker productivity. With increasing knowledge of proper personnel procedures the social efficiency of the worker becomes greater.

There have been some interesting studies of the analysis of occupations into their fundamental unitary traits. Kelly found the following traits to be necessary in the order named in a large variety of occupations; physical strength; verbal ability; a social trait; numerical ability; a trait of abstract intelligence; a drive or leadership trait; a memory trait; a religious trait; a motor trait; a general factor; special sensory activities; an interest factor; a spatial factor. If this be a complete list of the elements of the organization of the mind, it should be possible to devise a test for each element and to determine its relative importance for each special occupation. This inventory is probably not complete but it indicates a direction in which to proceed. Thurstone has also worked over the intercorrelations between the interests of eighteen occupational groups, as measured by the Strong Interest Blank, and found that vocational interests were reducible to those in science, language, people and business.

Vocational guidance also includes the important field of rehabilitation of the physically and mentally handicapped which includes those disabled by disease, accident, and war. Previously these were allowed to exist on a mere pittance or nothing at all in the way of help, making their ways in the world as best they could. With the aid of several government agencies which publish much material in this field regarding occupational information and the physical requirements for the various occupations many of these cases are now happily employed and have become useful members of society.

There has been an increasing interest in the psychological effects of various work enviromental conditions upon the output of workers. These include studies of the effects of highly specialized jobs on work output; studies of incentives on work output; effects

of distracting stimuli such as noise on work output; studies of illumination and atmospheric conditions on output, and studies of the effects of monotonous work on output. Highly specialized and monotonous industrial work tasks, such as putting the wrappers on bars of soap, are best done by people of a not too high degree of intelligence. To distracting stimuli such as noise in the work situation, if efficiency is measured in terms of output, the worker can make a surprising adaptation for at least a limited period of time. This is achieved by 'putting forth more effort' on the workers part and probably the expenditure of additional energy not commensurate with, but in excess of, the added work output. To varying degrees of illumination in a workshop the human eye can make surprising adaptations over a surprisingly large range of illuminations. The chief deleterious effect of poor ventilation in a room seems to be traceable to high humidity and lack of moving air to permit of proper evaporation of perspiration. In all these studies great individual differences were found in the manner in which the efficiency of the workers was affected. In short, worker attitudes are of great importance in any study of enviromental conditions on work output. This is true because practically all workers do not ordinarily work at top speed during the work day but have a reserve energy which can be thrown in whenever the worker's motivation is increased.

Concepts of human efficiency vary with the aspect from which industrial work is considered. Management usually considers the output of work as its criterion of efficiency; labor's idea of efficiency is output of work with a saving of energy expenditure on the part of the worker. The psychologist considers that the amount of satisfaction the worker gets from his job should also be written into an adequate concept of efficiency because the worker's attitude is an important variable in his efficiency. Poffenberger in his *Principles of Applied Psychology* thinks of the ideal of human efficiency as the production of the greatest amount of goods in the shortest time and in the highest quality with the smallest energy expenditure and with the greatest amount of worker satisfaction. Out of all of these studies one reaches the conclusion that the human being is a remarkably adaptable organism if his morale factor is kept at a high level.

The problem of industrial accidents has recently been studied by a number of authors. For example Slocombe found that in a plant employing several thousands persons that 20% of the workers accounted for all of the accidents in that plant but that a mere 6% of them were involved in 65% of all accidents that occurred there.

Thus some workers seem to be more susceptible to accidents than are others. While other factors such as speed of work, length of work period, etc., are probably factors, the personal equation is also important. Personality, interests, job attitudes, home conditions, marital attitude all seem to be important in dealing with the individual accident case. Accident clinics have been set up as a means of reducing accidents. In 1945 industrial accidents accounted for the loss in full-time employment of 218,000,000 employee-days according to Ghiselli and Brown in their recent book *Personnel and Industrial Psychology.* A better knowledge of the causes of accidents will of course be of great social significance.

Psychology of Old Age: The age-group 60 to 79 years is becoming an increasingly important one in the population of the country. In 1930 it represented about 7.8% of our population; in 1850 it was less than half that large. In another thirty years it is estimated that it will be almost 20% of the total population. Several books have been published regarding the problems of aging and several scientific symposia directed to consideration of its problems. In addition the U. S. Public Health Service in 1940 organized a research unit on the psychological and medical problems of aging. The mental hygiene of this period of life is in need of further clarification through study and is being studied.

With old age also comes a diminution in the *speed* of many motor and mental processes. It should well be remembered that the work of the world is hardly ever done at maximal capacity as most organisms operate on a "plane of ease" with respect to their work activities and possess many hidden powers which can be called forth in emergency. During the years of World War II older people, many of whom had retired, returned to active work and made an important contribution to victory in industrial plants and elsewhere.

Jones and Conrad found Army Alpha Intelligence Test Scores at age 58 to average about the same as that of a 15-year-old group. The peak for this test score was found to be at age 20. Such a finding does not warrant the frequently encountered assertion of middle-aged people that they are too old to learn and to adapt to new situations. At the age of 70 years the intelligence test score is about that of the average 10-year-old child. We certainly do not consider the 10-year-old child without capacity for learning. While it is true that older people do tend to become set in their ways of thinking and in their attitudes there is no reason why they cannot learn new things and such a view should not be encouraged as it gives

the aged a defeatist attitude and feeling of inferiority which discourages them from trying to do so. The level of achievement that any age group attains is related to interest and incentive as well as to capacity. In the adaptability of the various age groups, individual differences are the rule and not the exception. Such a philosophy will tend to make old people more contented and useful in the work of the world.

Educational Psychology: The focusing of psychological interest upon the individual and on individual differences has had a radical influence upon the work of the school. The testing movement was the base from which this principle was given reinforcement. In decades past the testing procedures chiefly involved measuring intelligence and achievement. But the realization that personality factors were of great importance in success in life turned a new interest upon factors influencing personality growth. Personality and aptitude testing interests have resulted from this appreciation and are the areas in educational psychology now to the fore. With the emphasis to a greater extent on social and personality training the child-guidance clinics, the vocational counseling service, and the school psychiatric service, the adults of tomorrow should be better adjusted in social and emotional ways.

As the increase in leisure time becomes greater in each decade the need for more adult education becomes apparent. Changing social conditions, more leisure time and the feeling of many older people that they did not have a chance for an adequate education in their youth give impetus to a growing movement.

Recent publicity has been given to glutamic acid, one of the amino-acids, as a booster of I.Q.'s. It is reported that this substance when fed in powder form each day over a period of time significantly raises the I.Q. Since this substance is found in eggs, wheat, milk and other foods perhaps a more adequate diet will have some significance for raising the general I.Q. of certain sections of the population. Zimmerman (1946) and his associates studied the effect of glutamic acid on mental functioning in children and adolescents and found the administration of 1 (+) glutamic acid to 9 subjects over a six-month period had a facilitative effect on psychological test scores. Maze learning in rats has also been facilitated by this substance. Zimmerman (1947) found this substance to have a facilitative effect on motor, verbal and Rohrschach test performance but more particularly on tests involving abstract thought than on those involving motor skill. A greater degree of emotional stability was

also noted in the experimental group. The most striking improvement in learning was noted in the seriously retarded group.

Personality Research: The appreciation of the rôle of personality factors in social living in all of its aspects has led to an increasing psychological interest in this field. The older idea that intelligence of the abstract verbal type was the most important variable of the human being in successful living is now corrected through a greater emphasis on personality development. The rôles of the ductless glands and the vitamins in effecting personality change are too important and apparent to need repeating. Much important work has been done along this line. The work of Sheldon and Stevens and others makes a strong case for a correlation between types of body build or between various bodily dimensions and personality and temperament. The correlations found between body build and temperament were in the region of +.80, which is very substantial. Cause and effect relationships are not clear but probably both body build type and temperament are caused in common by glandular constitution.

Social factors also seem to play a rôle in the development of personality and it is on this principle that modern education is partially based. Such factors as being the only child, living in a home in which the emotional climate is benevolent, the influences of the neighborhood and the gang, etc., are also apparently important in the development of certain aspects of personality.

Cattell's book on *Description and Measurements of Personality* (1946) reports work in which he attempts to bring into perspective the facts available regarding personality. Taking 286 studies which had been directed at the measurement and description of personality traits he offers a set of factors found in the application of his factor analysis technique to these data. Out of his analysis come twelve primary source traits manifested in these data. These factors are in reality twelve pairs of factors, e.g., *cyclothymia* vs. *schizothymia, general mental capacity* vs. *mental defect, dominance-ascendance* vs. *submissiveness*, etc. Work of this character is of great significance for the establishment of a logical or rational base for the comprehensive and systematic study of an important field which at a prior date was disorganized and in a semi-chaotic condition despite its great social importance. The work of Cattell must be considered a milestone on the road to better understanding of this all-important field.

Interesting tests like the Rorschach and the Thematic Appercep-

tion Test for the measurement of personality traits have been developed and are being widely used. These tests represent an advance in the methodology of personality measurement since they are relatively free from the effects of the tendency of the subject to be influenced by his judgment of the 'rightness' or the 'wrongness' of his answers, which is a shortcoming of the questionnaire types of personality tests. On the types of personality tests in which the subject answers questions there is a universal tendency to choose the answer the subject thinks *should* be chosen rather than the answer most truly descriptive of his behavior. In the Rorschach and tests of this type this tendency is largely avoided.

Thurstone's work in the measurement of attitude should also be mentioned as one of the monumental contributions to a better understanding of one phase of the personality. His factor analysis of intelligence into the seven primary functions, verbal comprehension, world fluency, spatial relations, number ability, memorizing, reasoning, and perceptual ability is important for a systematic comprehension of yet another important dimension of personality.

The Social Significance of Recent Developments in Science

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My colleagues on this symposium have reviewed for you the recent advances in biological science, in psychology, and in the physical sciences. They have called attention to items that seem to be of peculiar significance for the future of national and world civilization. They have indicated the trends and probable lines of further growth in these respective divisions. It is our task in a more general perspective to center attention upon the social significance of these recent developments and trends in the sciences. I would suppose that this is the reason that your program committee has invited a teacher of philosophy to introduce this discussion.

There are, doubtless, many different schemes of analysis that may be applied with equal validity, in considering the social significance of recent developments in science. I have chosen to center our thinking on six statements that seem to me to be items of unusual significance and concern.

I.

Growth in the body of knowledge of the sciences translated into social terms becomes increase in power to do. The step by step and stage by stage history of the advance in modern knowledge has spelled out in detail the meaning of the oft quoted conclusion, "knowledge is power." What we think of, in terms of the abstractions of the modern university, as systems of knowledge, the science of physics, the science of chemistry, the science of zoology, the science of botany, the science of bacteriology, the science of psychology, the science of economics—what we think of as systems of knowledge have social significance in the fact that they create actual physical tools which, put in the hands of men, increase their power to transform the objects of nature around them to sustain human life, to destroy human life, to extend the period of life itself, to mitigate suffering, to increase enjoyments, to increase the number and the location of the experience that individuals may undergo. A catalogue of these tools created by the sciences is without limit and beyond the acquaintance or comprehension of any contemporary. Of equal importance is the fact that growth in these systems of knowledge increases man's power to adjust himself to the stubborn and changeless conditions

of his living, and, on the other hand, brings it within his power to modify these conditions to his comfort or his pleasure or his health. There is strong witness to the fact that advance in science is growth in power in the fact that sciences have become matters of central concern in the negotiation of international relations.

This growth in potentiality results inevitably in an increasing complexity and interdependence of men and the forms of their social organizations. The creation of the tools, the manipulation of the tools, the use of the tools, created by the advances in scientific knowledge, require larger and larger groups of persons living in stable forms of social organization. The modern manufacture of shoes, the production of atomic bombs, creation, maintenance and operation of modern transportation systems and communication systems, cannot be accomplished by a few persons; they require thousands of persons. These processes themselves are interdependent and vastly increase the complexity and the unity of national and international organization.

This increased complexity and interdependence of modern social organization forced by advances in science means, inevitably, two things. One, an increasingly corporate society with diminishing individual freedom and, two, an increased range of significance of the social choices that must be made.

When we assert that the advances in science are bringing a more highly corporate character into social organization, we are not advocating a political or social policy. We are asserting neither that this tendency is good nor that it is bad. We are asserting that advance in science leads inevitably to a more highly corporate character of the society and that the only way to stop that trend is to stop the advance in science. The trend has the inevitability of established cause and effect relation. It is not a question of whether or not there shall be increased complexity, unity, interdependence and centrality of organization in human social groups. The question is rather what we shall do with this trend.

The increasing complexity, interdependence, corporate, character of society means, of course, diminishing individual freedom. It means also, I would suppose, a drift toward a totalitarian state, but it does not mean that inevitably. It means that the preservation of freedom through democratic processes becomes more important than ever before. The issue is forced; it cannot be avoided. It is one side of the social significance of the fact that advance in science means increase in human potentiality, in power.

The other aspect of increasing interdependence and complexity is the fact that the choices made within such a society are very greatly extended in range and in significance. It hardly needs to be pointed out that so long as knowledge in the sciences created instruments for destruction no more deadly than a bow and arrow, human hatreds, distrusts, fear, and selfishness were not nearly so dangerous as in a period of civilization when knowledge of the sciences creates an instrument like the atomic bomb. The number of the choices and the importance of the choices that the man with that more primitive instrument had to make were not nearly so great as those that confront men in what we are pleased to call, "the atomic age." Your knowledge and imagination will extend the application of this observation to hundreds of other areas. It is advance in human potentiality with the consequent increase in complexity and corporate character of society that places new demands of range and significance on the choices of the laboring man, the business executive, the teacher, and the housewife, as well as the legislator.

II.

The recent advances and trends in development in the sciences require that we rethink the role of the investigator, the teacher, and the engineer. It is one of the weaknesses of our culture that we have no commonly accepted code of ethics to guide the work of the scientist. The traditional elements of a personal code extend no farther than the demands of truthfulness, honesty, kindliness, and industriousness. It is not suggested that these elements of a personal code are any less important today than they have been in the past. On the contrary, they are probably more important than ever before. The point is that they are elements of a personal code. They are principles for the guidance of behavior individually conceived. They do not take into account the complex social consequences of the professional activities of the modern scientist.

In the last four years, scientists all over the world have become increasingly aware of the need for the development of such a code of ethics. Will you permit me to quote from the eminent British biophysicist, A. V. Hill, "If standards of truthfulness, frankness, and integrity are relaxed either for political motives or for private ambition and gain; if fraud, dishonesty, and self-deception are not denounced; if mistakes are not honestly acknowledged and corrected, if propaganda is accepted in place of fact; if the common prestige and good will of science are prostituted for base, sectional, or selfish

purposes; if secrecy or secretiveness is accepted as a normal condition of scientific work; if age, prestige or authority, if race or nationality, is allowed to hinder freedom of intercourse or equality in interchange of ideas between scientists of honesty and good will anywhere in the world; if scientists allow themselves to be conscripted for the purposes of power politics; if, finally, there is widespread failure to recognize an unbreakable obligation—as it should be—that the benefits of scientific discovery must be regarded as a sacred trust for all mankind; if all these things fail, then science itself may become impossible as a vocation for free, honest, and decent men, while its exploitation for sectional gains or national aggrandizement may lead to conflict and destruction instead of cooperation and betterment." With this series of warnings, Dr. Hill goes on to propose his own personal statement of a code of ethics, "Scientists have the right, and indeed the bounden duty, to question and argue the nature of their own calling and its own special contribution —and its danger—to national and international welfare. They should feel an honorable and unbreakable obligation to keep the scientific truth of frankness, honesty, courage, and sincerity; to avoid secrecy, whenever possible, as a condition of their work; to treat all honest scientific men anywhere as co-workers in a common cause; not to exploit the common property of science for base or selfish ends; and to refuse conditions of employment or advancement, however attractive, that do not meet the ethical requirements of what could be—and should be—one of the most important common interests of mankind. I would add further a duty, one of the most important and one about which many scientific men today feel very strongly, namely, to refuse to cooperate at all in tasks in which they, or their representatives, are not allowed a reasonable share—I say reasonable, not dominant—a reasonable share or partnership in the responsibility of deciding on the purpose, or the policy, or the probable outcome of their work."

I do not know whether or not these principles of Dr. Hill's are acceptable to you as a code of ethics for the guidance of all workers in the field of science, but I am very sure that the community of scientists must, by open discussion and conference, evolve such a code and find it so deeply engrained in the consciences of their co-workers that they can assume it as the basis of action of all members of their fraternity. Such a code of ethics is not a bill of particulars specifying privileges sought, it is a statement of principles essential to the welfare of the society and to the growth and development of science in it.

III.

The third item of social significance in the recent development of science to which I would call your attention, has to do with the organization of research.

For nearly four hundred years, research in the sciences has been carried on by the individual working alone in his laboratory. The story of research is symbolized in the work of individuals like Kepler, Newton, Lavoisier, Mendel, Darwin, Helmholtz, and their colleagues in the list of the great. But in the last ten to fifteen years, research work in the sciences has become a very different kind of enterprize. I do not know of a single fundamental problem of research in the sciences that can today be advanced very far by the work of an individual in isolation. All of the major problems commanding the attention of present day scientists are group problems. As group problems, they require complex organization to support them. Parallel to this new group character of research is the very great increase in cost and complexity of the instruments used.

Within the past week it has been announced that the United States Government would build a new cyclotron to be used in research in physics on the campus of the University of California. It is to be noted that this instrument will not be the property of the University of California, but the property of the United State Government, located on the campus of the University of California, and that is a very different matter. The cost of that instrument was over nine millions of dollars. We are meeting on the campus of a college with adequate buildings, beautiful landscaping, and competent equipment. I do not believe that I would be far wrong in estimating that the cost of that one instrument of scientific research, located on the campus of the University of California, is greater than the total cost of all of the buildings, books and equipment of the institution that is today our host. This change in the character of research to the work of complex groups and the very greatly increased cost of the instruments that they use, is a matter of far reaching social significance. It has meant that much of the research in the sciences has moved outside of the universities and into large institutes under the auspices of government or of business. Research under the auspices of government, so long as that government is truly democratic in its control, is no cause for alarm. But the same kind of centralized organization can become a perfect instrument for a totalitarian state. To illustrate how easy is this tendency toward totalitarianism, I will quote one sentence from a recent address by Dr. Vannevar Bush. I

would like to think that Dr. Bush was unaware of the implications of his statement, but whether he was aware of it or not, it is a perfect example of fascism. "Our planning in science must be for a strong United States, strong industrially, economically, socially, and during the interim years, in a military sense." If that sentence were typical of the thinking of many of the scientists of the United States, it would be cause for genuine alarm. But I am confident the social intelligence of the great body of our scientists would be cause for its repudiation.

The movement of research into the control of private industry has progressed at a very remarkable rate. It had been the policy of our largest chemical and electrical concern to subsidize research inside the universities up until the beginning of World War II. But in the last eight years, there has been a very rapid development of research institutes in the organization of business concerns. This, of course, has been fostered by the fact that during the war the cost of these institutes was borne wholely by the federal government through the device of deductions from excess profits tax; and since the war, approximately 84 per cent of the cost has been borne by government in other forms of tax reduction. This movement of research into the hands of private industry means that much of the future advance of the sciences will come under the patents and licensing system, which is itself a concentrated source of social power.

IV.

In the late summer of 1945, the President announced the use of the immensely destructive atomic bomb on Hiroshima. A part of that announcement was the statement of his intention to create a public commission, divorced from political control, which would guide the further development and use of atomic energy. The decision of the President announced at that time has never been seriously questioned. The possibilities of peace-time use of this new source of power were so great that the agency controlling it would be in a dominant position for the control of the entire economy of the nation. It was obvious that such power could not be committed to a private corporation. The future may very well prove that this decision changed the entire pattern of the economy of the United States, making it at least half socialist in character. I am not suggesting that any other decision could have been made, but this is one of the recent developments in science which has had very far reaching social sig-

nificance and, of course, it has been some dim awareness of this fact that has called forth the behind-the-scene struggle over policies and personnel of the atomic energy commission.

V.

The last fifteen years have seen the end of a technological lag in our culture, and this fact is a very important one for the future character of higher education. At the end of the Civil War we were a nation with a great heritage of scientific knowledge developed largely in European centers, but with a great gap between that knowledge and its application to human uses. Some recognition of this fact created the first of our technological institutes and shaped the character of American technological education. The rapid growth of engineering and manufacturing processes that resulted from this emphasis on technological education, of course fed back into the demand for more and more personnel so trained. During these past seventy years, the demand for personnel has been so great that technological education has been concentrated in the specific vocational field denying to the individual student the opportunity for competent education in the areas of the humanities, and the social sciences.

Within the last ten years, we have seen the closing of the gap between the advance in knowledge of the sciences and the application of this knowledge to human affairs. We are now at the point that further technological advance can move no faster than does basic research. This means that there is not so great a dearth of technologically trained personnel and there is opportunity for revision of the curricula of technological schools that will permit students to move at a more leisurely pace toward professional competence, thus permitting their education as citizens and persons as well as technicians.

VI.

In summary, all of these recent developments in science point to one clear demand, and that is for the application of critical intelligence to the solution of social problems and to the motivation that controls them. This can be graphically illustrated in contrasting the interests and outlook that are actually characteristic of the people of our generation with the possibilities that are within the grasp of this generation.

In this generation it can be said for the first time that we have the knowledge, the tools, and the trained personnel to produce enough

food for all the people to have a well-balanced diet. For the first time, it can be said that we can provide adequate housing for all of the people. We have the knowledge and we know how to train enough persons to provide adequate medical care for all the people. For the first time, it can be said that we know enough about cause and effect relations in the sphere of economic activity, that it is possible to maintain a highly productive economy on a stable basis. For the first time, it can be said that we know enough about the cause and effect relations in the realm of the behavior of national groups, that we could write the conditions, economic and political, for a permanent and an enduring peace. In this generation it is possible for the first time through radio and recorded music to bring the best in music to all of the people. We know enough about color reproduction to bring very nearly the best in art to all the people. It can be said now that we know how to provide the material conditions for the good life for all men. In a situation like that it might be assumed that this generation would be filled with a great enthusiasm for the possibilities of tomorrow. Instead I hear men asking anxiously whether or not they can avoid another war, whether or not they can avoid depression—in sum, men of our generation are ridden by their angers and their fears and their doubts. This angry, fearful, doubtful generation needs the application of critical intelligence to the solution of its social problems and to the motivation that controls them.

Report of the Academy Conference at the Washington Meeting of the American Association for the Advancement of Science.

The Academy conference met in the District room of the Statler Hotel, Washington, D.C., Sept. 17, 1948, from 3 to 5:45 p.m. with A. O. Weese presiding. From 25 to 40 delegates and visitors were in attendance. Four papers were presented and discussed freely and at length.

Frank Thone of the Washington Academy presented a paper on Federal aid for science, bringing out particularly the point that the people of the United States are in favor of such aid but that Congress and the President want agreement among scientists regarding leadership. The President also wants to appoint the director of science with the concurrence of the Senate. The program calls for establishment of a National Science Foundation, part of whose program will be the establishment of scholarships and fellowships. At present much of the general basic research is being done under Navy auspices but the Navy would like much of it to be under civilian direction.

The Natural Science Foundation had better be developed first. A Social Science Foundation will follow easier than to try to do the whole thing right away.

State Academies will come into the picture, it is hoped, by being the certifying agency or the agency for recommending candidates for scholarships and fellowships, since it is felt that academies will be closer to the source and know more about prospective candidates.

J. M. Aikman of Iowa told what the Iowa Academy of Science has done to promote conservation of natural resources. An active academy committee has vigorously supported the fine state park system of Iowa and is attentive to new conservation developments.

Academies should endeavor to organize the conservation work of the states.

Frank C. Gates, of the Kansas Academy, presenting the results of a survey of affiliations with scientific societies and industrial research organizations of the state, brought out the fact that over half of the academies have affiliates among scientific organizations but only one-fifth of the academies have formal cooperative relationships with industrial research organizations in the state and that

these were mostly of an educational or talent search nature.

Only six or seven academies award scholarships.

A little less than half the academies maintain state talent search programs. Discussion brought out that academies should play a part in selecting persons for undergraduate scholarships. They should also provide scholarships, if possible, but in any case should afford all recognition possible to scientific talent.

James L. Liverman, representing the Texas Academy, took up the history of the collegiate academy from its inception in 1937 and gave as its present status: Three (Ill., La., Mo.) with collegiate membership in a separate collegiate division; eight academies have collegiate membership in the senior academy; one (Mich.) has collegiate membership in the junior academy, but, in making awards for merit, three levels are recognized: collegiate, high school, and junior high school. This report was followed by an account of the history and mechanics of operation of the Texas Academy, collegiate section.

Dr. F. E. Germann, of the Colorado-Wyoming Academy, was elected chairman of the December, 1949, meeting and Dr. A. R. Middleton, of Kentucky, was continued as secretary.

Following the banquet, Dr. Karl Lark-Horovitz discussed developments of science in Europe and America during the past 100 years, bringing out particularly how symbolic expression used to follow observation and discovery, whereas now it is likely to precede them, and how the lag between discovery and application has been tremendously shortened, during the past century.

A. A. A. S. Round Table

For the first time at this meeting the Council of the A.A.A.S. set up a round table on the subject "Methods of Encouraging Young Scientists." It met from 9:30 to 12:15 Friday, Sept. 17, 1948. The meeting was attended by about 125 and participated in by about 20. A few of the more important things brought out included:

Enrollment in physical science courses jumped from about 7% to about 25%, as a result of the part played by science in the war. On the basis of comprehensive testing, however, the passing element increased only 1%. In other words, about as many are entering science as have the ability to succeed with it.

Great biologists get their start in biology at about 12 years of age.

Great physical scientists start at 14 years.

Opportunities for interesting biologists should start at least

in the upper elementary grades and junior high school.

While an enthusiastic teacher may be a help, a properly lazy teacher who gets his students to do his work has most often had his students win the science awards.

The development of an intervening level between high school and college which might separate the training of technicians as against scientists is worth considering.

Subject-matter teachers should have at least equal weight with educationalists in formulating laws which govern the certification of teachers.

Establishment of workshops and information on how to procure and make use of low cost equipment is one of the best teacher-training programs.

We need a citizenry intelligent in science to appreciate properly the work of scientists.

The hope was expressed that more states will institute talent search programs.

F. C. GATES,
Academy Delegate

Sept. 18, 1948

Kansas Academy of Science—Report of the Treasurer

March 27, 1947 to April 27, 1948

Receipts

Balance in checking account, March 27, 1947	$1,364.35	
Annual dues for memberships	1,614.25	
Life Membership	30.00	
Life Members' payments for Transactions	71.00	
Honorary members' payments for Transactions	3.00	
Sale of Transactions	39.85	
Sale of Winter Twigs	32.94	
Reprints	673.96	
State of Kansas	1,000.00	
Exchange Rights (Kansas University for 1946-1947)	200.00	
One Academy Handbook No. 1	.20	
Refund from Markwell's Bookstore, Hays, Kansas	3.50	
Interest on Investments	66.98	
Western Shares (final distribution)	23.63	
U.S. Savings Bonds (final distribution),	800.00	
		$5,923.66

Disbursements

Secretary—stamps, help, stationery, etc.		$ 99.50
Treasurer—stamps, bond premium, bank box rent		24.97
Managing Editor—expenses		74.30
Executive Council Members Mileage—May, 1947		21.06
Annual Banquet and lapel badges		15.41
Junior Academy Awards		8.00
First National Bank, Hays, Kansas—for returned checks		13.50
Edith Beach—expenses for state meeting, 1947		3.37
Ralph Rogers—Junior Academy expenses		15.02
Guy B. Homman—postage for Science Teachers Section		1.20
W. J. Argersinger—refund for reprints		10.00
William Taylor—refund, Vol. 1 of the Transactions		1.00
Edwin R. Walker—expenses to Wichita meeting Nov. 1947		12.60
John Frazier—expense to A.A.A.S. meeting		25.00
Frank C. Gates—expenses to Chicago Conf. Dec. 2		26.34
John A. Davis—postage (Chemistry Section)		1.50
Workman Printing Co. (programs, stationery, etc.)		97.00
Elliott Addressing Co. (stencils, postage)		4.82
The Outlook (paper, envelopes)		185.24
Editorial Board		
The World Company No. 22686	$ 484.10	
The World Company No. 23242, 23700 + 28.86	1,261.46	
The World Company No. 24177	519.30	
The World Company No. 24609	710.65	
The World Company No. 25095	632.78	
The World Company No. 25476	674.55	
Capper Engraving Co. No. 6001	6.19	
Capper Engraving Co. No. 6192	26.71	
Capper Engraving Co. No. 6334	14.61	
Capper Engraving Co. No. 7093	31.92	
Capper Engraving Co. No. 7169	87.11	

Capper Engraving Co. No. 7739	124.67		
Capper Engraving Co. No. 7763	5.83		
Capper Engraving Company No. 7872	18.02		
Capper Engraving Co. No. 8529	115 60		
Capper Engraving Co. No. 9320	127.45	4,840.95	
		$5,480.78	
Balance in checking account, April 27, 1948		442.88	
			$5,923.66

Supplementary Statements

Outstanding checks No. 9, 46, 51, 52, 53		$1,447.18
Accounts Receivable		
Library exchange, Kansas University	$ 250.00	
Library exchange, Kansas State College	250.00	
Library exchange, Fort Hays Kansas State College	125.00	
Reprints	180.90	805.90

Investments

In Endowment Fund	$3,294.53	
In general fund, interest on endowment fund	420.58	
		$3,715.11

Awards Account

Amount in fund March 27, 1947		$ 175.90	
Received during the year:			
Reagan Bond	$ 25.00		
A.A.A.S.	00.00	25.00	
Total		$ 200.90	
Awarded—to Leon Lungstrom for 1947	$ 60.00		
to Austin B. Williams for 1947	100.00		
Amount paid	000.00	000.00	
Balance			$ 200.90

STANDLEE V. DALTON, *Treasurer.*

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Original articles are entered under the name of their fields (Archeology, Chemistry, etc.), under the name of the author (given in italics) and under the title, usually abbreviated (and also in italics).

Transactions

OF THE

KANSAS ACADEMY OF SCIENCE

Established 1873

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For Contents, see Index, Page 520

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Manuscripts for publication or other communications concerning the *Transactions* should be addressed to the editor, Dr. Robert Taft, University of Kansas, Lawrence, Kansas.

Correspondence concerning exchange privileges should be addressed to the director of one of the following libraries:

1. University of Kansas, Lawrence, Kansas, or
2. Kansas State College, Manhattan, Kansas, or
3. Fort Hays State College, Hays, Kansas

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Volume 52, No. 1, March, 1949, issued March 22, 1949

Volume 52, No. 2, June, 1949, issued June 21, 1949

Volume 52, No. 3, September, 1949, issued October 18, 1949

Volume 52, No. 4, December, 1949, issued December 31, 1949

Transactions
Kansas Academy of Science

Volume 52, No. 1 March, 1949

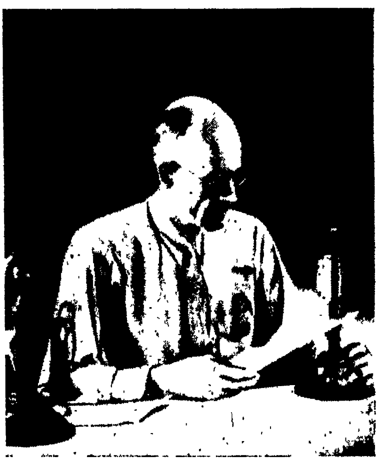
Kansas Weather: 1948

S. D. FLORA
Meteorologist, U.S. Weather Bureau, Topeka

As has been our practice for several years in the March issue of the Transactions, we present Mr. Flora's annual summary of Kansas weather for the preceding year. Mr. Flora, well-known to several generations of Kansans, has been associated with the Topeka office of the U.S. Weather Bureau for over 40 years but has announced his retirement which will take place May 31. His name on these annual reports will be greatly missed. During the past year, he published the comprehensive Climate of Kansas, an exceedingly important addition to Kansas scientific literature.

—The Editor.

1948 gave Kansas exceptionally favorable crop growing weather, a summer that was considerably cooler than usual, and a long stretch of fine Indian summer weather in the autumn. Along with this fine weather the State had almost record-breaking snowfall, several unusually severe blizzards in the western counties, and overflows in all rivers, with record-breaking or near record-breaking floods along the Cottonwood and Neosho Rivers.

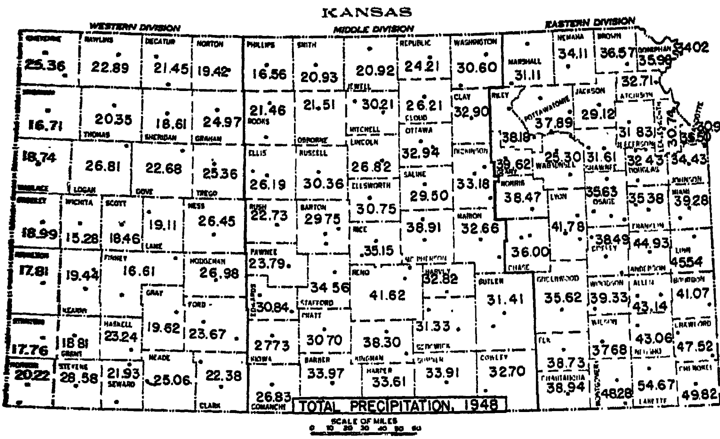


MR. S. D. FLORA

The year's precipitation was above normal in almost every part of the State and occurred at opportune times for crops. The average for the eastern third was 37.18 inches; the middle third, 30.62 inches; the western third, 21.05 inches; and for the State as a whole, 29.48 inches, which was 2.53 inches above normal and exceeded amounts during either of the two preceding years. The greatest fall was 54.67 inches at Oswego and the least, 14.73 inches, at Long Island, Phillips County. Almost half the year's rain fell in June and July, just when corn and many other crops needed it the most.

The average snowfall of the year for the State as a whole was 35.5 inches; which exceeded the amount in any other year, except 1924, since the State wide record was begun in 1887. Almost half of this fall occurred in March and when it melted left an abundant supply of soil moisture for spring growth of crops.

The year averaged the coolest the State had experienced since 1929. Each of the three summer months averaged abnormally cool. The highest



temperature reported was 108° on June 17 at Ashland, Lakin, Medicine Lodge, and Syracuse, a mark that has been exceeded in every year, except 7, in the past 61 years. The lowest was -25° on March 11 at Healy, Oberlin, and Quinter, breaking the record for low March readings at each of those places.

The year began with a three-month period that was a near record breaker for cold weather and heavy snows, holding spring work in abeyance, but making favorable conditions for wheat. This winter weather was followed by the warmest and one of the driest Aprils on record and warm and comparatively dry weather in May, which enabled farmers to complete spring planting, gave corn, alfalfa and pastures a fine start, and enabled wheat to develop.

Wet weather through June and July was especially favorable for corn. Wheat harvest was delayed somewhat but was generally completed in July, with exceptionally fine yields. There was sufficient rain to complete the growth of corn satisfactorily in August, except in some

northcentral and northwestern counties, and warm, dry weather in September favored husking.

Early fall months were too dry for the new wheat crop but November precipitation, which in the western counties came as heavy snow, followed by good growing weather the first three weeks of December, put wheat in good condition for the winter.

SEVERE STORMS OF YEAR

Tornadoes, windstorms of other nature, hailstorms, and blizzards were unusually destructive during the year. A total of 17 tornadoes was reported, with damages estimated at $2,076,500 and a loss of two lives. Nearly all of this damage occurred in May and June. The most destructive tornado of the year was one that originated four miles southwest of Wichita on June 21, with the chief damage in the southwestern part of the city. Losses from it were estimated at $1,000,000 and 12 persons were injured, though no lives were lost. The second most destructive tornado, and the only one attended by loss of life, occurred in Neosho County on May 1, passing near Thayer. Buildings on more than 60 farms were badly damaged or completely demolished. Five persons were injured and two killed. Property losses were placed at $500,000.

Windstorms of other nature, of which 37 were reported, were exceptionally destructive, with losses from such outstanding storms as were reported totalling $12,186,500. Two lives were lost. The most destructive of these was one that swept over Barton, Rice, Reno, and Sedgwick Counties on July 11, with losses totalling $8,730,000 and one life lost. Damage was especially severe in Nickerson, Hutchinson, and Wichita. At the two latter places damage exceeded that of any previous storm on record. The second most severe windstorm of the year occurred in McPherson, Harvey, and Marion Counties on June 15, with damages totalling $2,150,000.

A total of 53 hailstorms was reported, with losses estimated at $8,726,400. Many lesser losses that were not reported also occurred. Most of the year's hail loss occurred, as usual, in June, when wheat was approaching harvest. The outstanding hail loss of the year, which exceeded the loss from any other Kansas hailstorm on record, occurred as a family of hailstorms in Cheyenne, Rawlins, Sherman, and Thomas Counties on the late evenings of June 13 and 14 and near midnight of the 15-16th. Losses were estimated at $4,450,000. Large areas of wheat were totally destroyed and farm buildings damaged. The second greatest hail loss of the year was a million-dollar loss to wheat in Logan and Scott Counties on July 16.

Two especially severe blizzards struck the State during the year. The first occurred in the southwestern counties on February 10, and continued through most of the 11th. Highways in many places were blocked for three days and schools were closed in Ford, Meade, and Scott Counties. Three persons lost their lives near Meade. The second blizzard, which was even more severe, swept across the state on November 18 and continued for 48 to 72 hours. All traffic by rail and highway was stopped and communications and power lines were down. Several hundred persons were marooned in their automobiles, in some instances for 24 to 36 hours. Two lives were lost. Losses to cattle and sheep were severe, amounting to several millions of dollars. Another blizzard of less intensity occurred in the western counties on November 27-28.

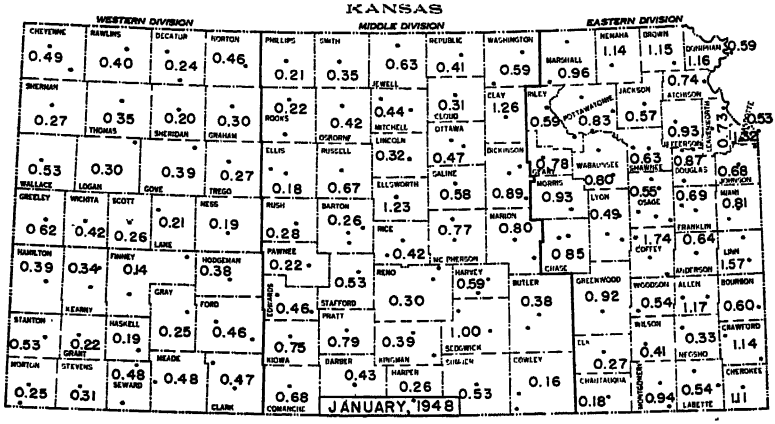
OVERFLOWS OF THE YEAR

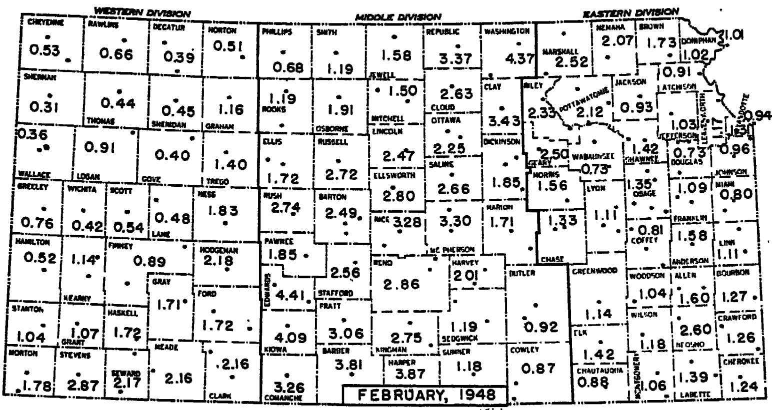
All of the important rivers of the State overflowed at least once or twice during the year with losses totalling $16,095,975, according to preliminary estimates. The greatest overflow of the year occurred along the Cottonwood and Neosho Rivers July 20-27 with crest stages that approached, and in some cases exceeded, all previous records. Most of Burlington and much of Iola and Chanute were flooded but more than half the damage, which totalled in excess of $10,000,000, was to growing crops. Slight local overflows occurred in the Neosho in March and in the lower Cottonwood in May, with a near record-breaking overflow of the Neosho at Parsons and Oswego in June.

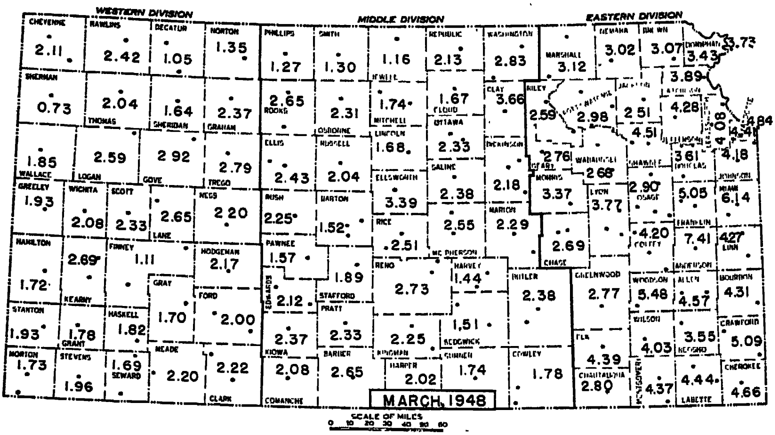
The Solomon River overflowed slightly at Beloit in June and very seriously in its lower reaches in July, with record-breaking or near record-breaking stages at Minneapolis and Niles. Damage along this river was placed at $1,286,175.

A great overflow of the Verdigris occurred in July, with losses estimated at $1,110,000. A slight overflow of that stream also occurred at Independence in June.

In the Arkansas basin, torrential rains the latter part of February in eastern Reno and northwestern Sedgwick Counties flooded highways, railways, and basements in several small towns. The Little Arkansas River also flooded slightly about the same time. In June slight to moderate overflows occurred along the Little Arkansas, along much of the Big Arkansas, and in the Ninnescah. In July a moderate overflow occurred in the Little Arkansas and a rather serious overflow along the Big Arkansas from Great Bend to the Oklahoma line. Cow Creek flooded Hutchinson, with great damage. A slight overflow occurred at Great Bend in August. Losses in this basin were estimated at $1,036,000.







Rainfall by Months.

The Little Blue and Big Blue Rivers overflowed the latter part of February and again the latter part of March. Early in August the Blue overflooded slightly at Randolph. On August 3 torrential rains in the basin of Black Vermillion Creek resulted in a record-breaking overflow and great damage at Frankfort. Losses for the year in the Blue basin were estimated at $907,240, most of which occurred at Frankfort.

The Marais des Cygnes (Osage) River overflowed at and below Osawatomie in March, with an overflow along Pottawatomie Creek. In July the Marais des Cygnes staged an overflow from its source to the Missouri line, which was prolonged sufficiently to cause great crop losses. Losses in this basin were estimated at $354,000, nearly all of which were to crops in its lower reaches near the State line.

The Kansas River overflowed slightly at Manhattan in March. In July it overflowed seriously at Ogden and moderately from that point to Lecompton. Torrential local rains in the vicinity of Dover, about 18 miles southwest of Topeka, on August 1-2 flooded Mission Creek and its tributaries, with losses totalling $50,000. Losses along the Kansas basin for the year were estimated at $172,000.

There were slight local overflows along the Republican in June, followed by a slight overflow at Clay Center in July and extensive flooding of creeks in that vicinity. Damage in this basin in Kansas was estimated at $208,160, most of which occurred in the vicinity of Clay Center.

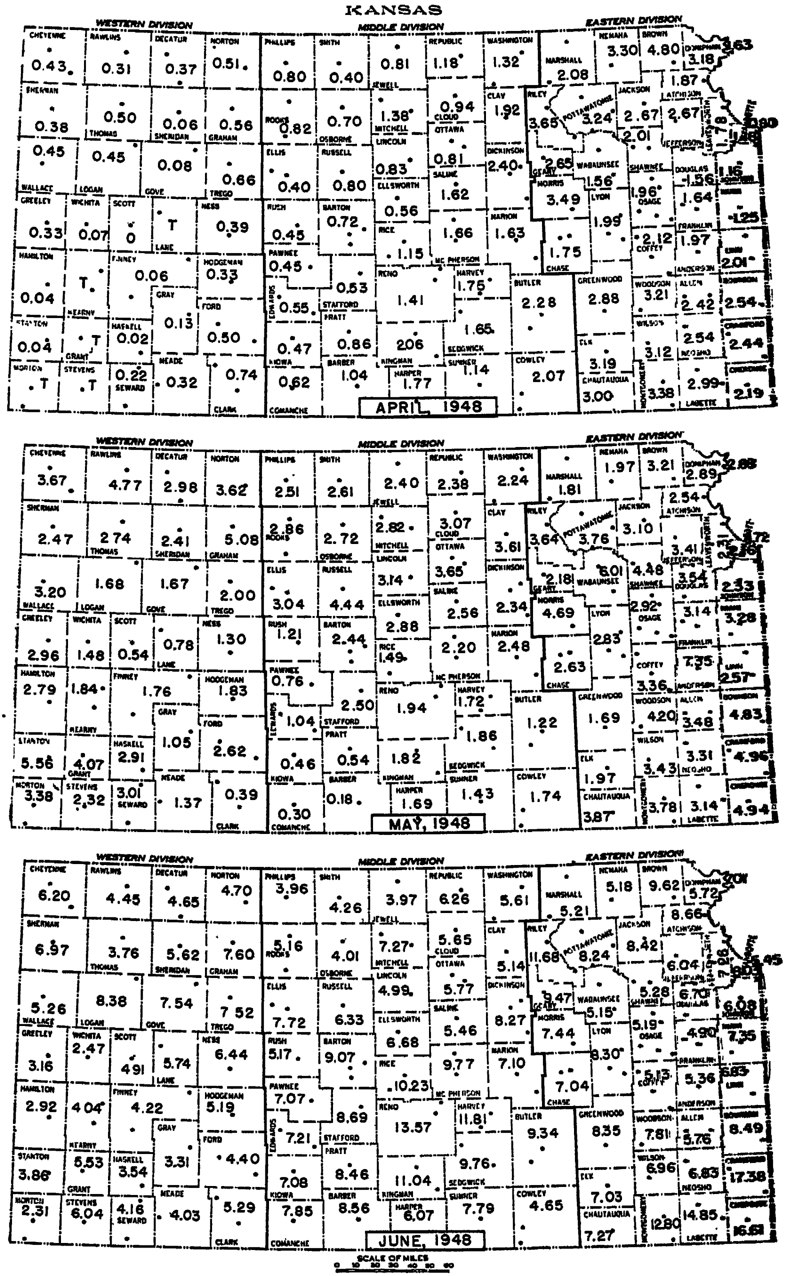
The Saline River overflowed moderately in July. A rather serious overflow occurred along the Smoky Hill at and below Abilene in July, with losses estimated at $158,200. This resulted largely from high water along the Solomon.

All estimates given in this connection are of a preliminary nature, subject to further changes.

THE WEATHER BY MONTHS

January

This month was the coldest January in eight years and had more snowfall than any other January in that time. It was a favorable month for wheat but was not so good for livestock. Temperature ranged below normal almost continually after the 12th, with sub-zero readings on several days near the close. Snowfall generally totaled four to 10 inches, except in the southeastern counties, where it was slighter.



Rainfall by Months.

February

This month was the coldest February in nine years and had more snowfall than any other February in 20 years. It was an unusually cloudy month. Snowcovered fields and abnormally low temperatures prevailed almost without a break during the first half, with considerably milder weather during the latter half. Average snowfall over the State was 5.6 inches, which was approximately 25 per cent above normal. Field work was held in abeyance, partly on account of cold weather the fore part and partly due to muddy fields in the eastern counties during the latter part.

March

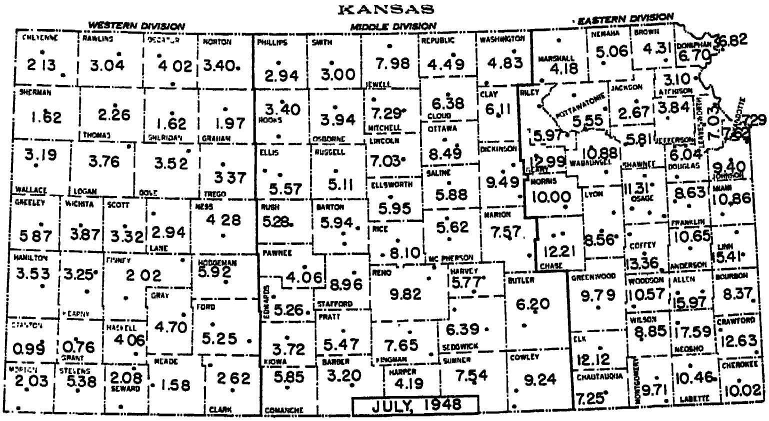
Record-breaking snows and low temperatures made this a wintry month. Snowfall totalled 15 to 25 inches or more over most of the western half and the northern counties and five to 10 inches elsewhere. Most of it fell during the first 10 days, culminating in blizzard conditions over most of the State on the 9th. On the 11th temperatures dropped below zero in all western counties with an extreme low of -25° at Healy, Oberlin, and Quinter. Low March temperature records were broken that day in nearly all parts of the State. Wheat was protected by a good snow covering during the extreme cold weather and materially benefited by the added soil moisture. Farm work was seriously delayed. Oats sowing and planting potatoes in the Kaw Valley were hardly started.

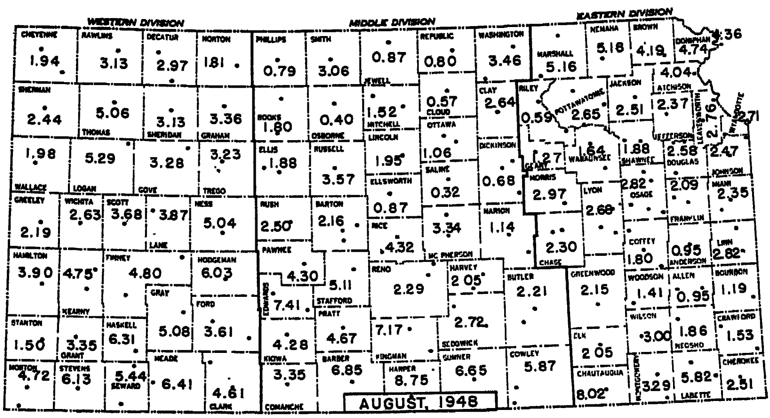
April

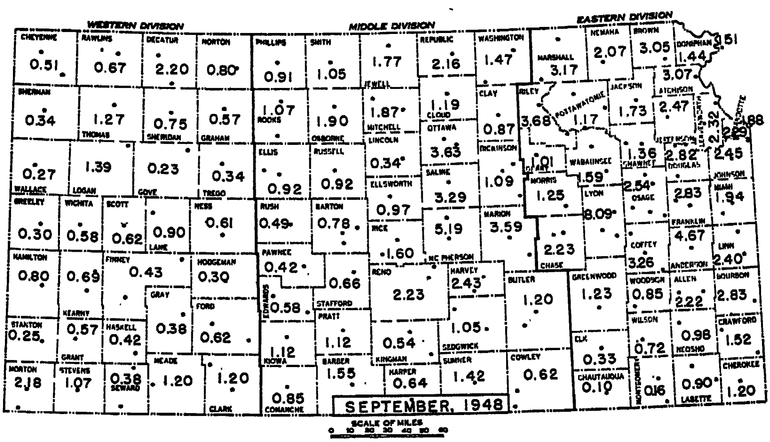
This month was the warmest April on record in Kansas and one of the driest. In the western half it was a very unfavorable month for wheat. Readings of 90° or higher occurred on one or more days in nearly all parts and the month's average temperature was 6.2° above normal. Much wheat in the western half failed to stool properly and made little or no growth. Pastures and alfalfa in the eastern half generally made a good growth. Corn planting began in the eastern half almost to the northern border.

May

Warm and, in many places, dry weather continued this month. Less moisture fell during this and the previous month than in any other April and May since 1937. In the south-central counties, afternoon temperatures on some days rose above 100°, with an extreme high of 104° at Medicine Lodge on the 21st. Wheat developed rapidly but its condition varied widely. By the close it was beginning to ripen in the south-central and southeastern counties. Corn made a good growth. Pastures and alfalfa were in good condition, except in the especially dry areas.







Rainfall by Months.

June

Warm weather and near record-breaking rainfall made this a very favorable month for crop growth. In many western counties severe hailstorms took a heavy toll of wheat. The average rainfall for the State was 6.57 inches, which was the third greatest on record for June. It was an especially favorable month for corn, which by the close was tasseling as far north as the Kansas River and making a luxuriant growth. Wheat harvest began in the southeastern counties during the fore part but was practically suspended by frequent rains. Pastures and alfalfa were exceptionally good.

July

This month was the wettest July on record in the State. The average was 6.09 inches, which was almost twice the normal. The greatest monthly total was 17.59 inches at Erie. Temperatures averaged below normal but high humidity made many afternoons and evenings very trying. Record-breaking or near record-breaking floods occurred along the Cottonwood. Neosho, lower Solomon, and lower Smoky Hill Rivers. It was an exceptionally favorable month for corn, other cultivated crops, and pastures. Wheat harvest was generally completed, with bumper yields.

August

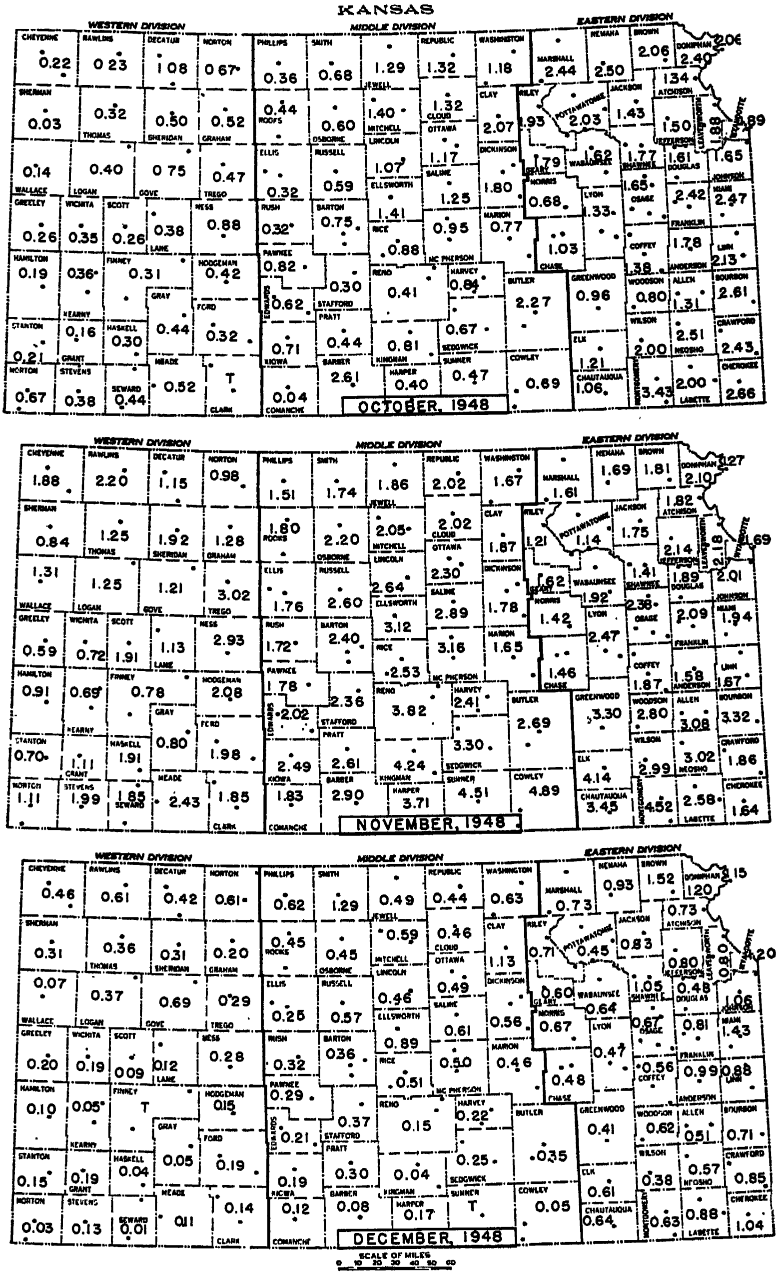
Soaking rains, many of very local occurrance, fell over most of the southern and western parts of the State, with a rather general deficiency in rainfall in many east-central and north-central counties. The first half of the month was pleasantly cool, while the latter half was much warmer with afternoon temperatures rising well into the 90's and exceeding 100° on one or more days over the northern and western counties. It was a favorable month for corn except in some north-central and northwestern counties. By the close, much of the crop had matured and was ready for immediate feeding.

September

Rainfall this month was decidedly deficient and temperatures averaged considerably above normal, with a great deal of fine sunshiny weather. Readings of 100° or higher occurred on one or more days in the north-central and western counties. Corn matured rapidly and by the close 50 per cent of it had been husked in some areas. From 80 to 90 per cent of wheat seeding was done in the western counties. Deficient topsoil moisture hampered the growth of the crop in nearly all localities.

October

Exceptionally dry weather prevailed over all the State, with temperatures averaging near normal and a fine spell of "Indian Summer" weather



Rainfall by Months.

that lasted almost three weeks. The average rainfall for the State was scarcely more than 50 per cent of normal and the least for October in nine years. Wheat came up and made a good start in most western counties, largely as a result of ample subsoil moisture from generous summer rains. Over the eastern part its growth was poor. Corn was mostly husked and harvest of grain sorghums was well along.

November

Generous amounts of precipitation fell. Mild weather during the first half favored growth of wheat, which improved materially. All pastures improved. The most severe November blizzard on record swept over the western half on the 18th with losses to cattle and sheep, especially the latter, totalling millions of dollars. In some localities five per cent of cattle and 25 to 40 per cent of sheep were lost.

December

This month was comparatively mild and pleasant but decidedly deficient in precipitation. The average amount for the State was approximately half the normal and less than a fourth of the fall of December one year previous. Snowfall mostly occurred during the closing week and was rather heavy in many northern counties but light to the south. The first three weeks were mild, but the last week was abnormally cold. Wheat went into the winter in very good condition. On the 27-28th snow and freezing rain fell in the northwestern counties with very high winds and blizzard conditions. Highways in most parts were exceedingly slippery on and near Christmas Day.

❖ The Editor's Page ❖

**Transactions
of the
Kansas Academy of
Science**

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OFFICERS

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Vol. 52, No. 1 March, 1949

ROBERT TAFT, *Editor*

In writing the news notes for this issue, the editor's mind constantly returned, for some odd reason, to the figure 81 which appears in the first news note in this issue. The 81st meeting of the Academy will soon be held! If we could drop in briefly at each of the 80 preceding meetings there could be written a whole history of science in the state which, in turn, would reflect the advance of science everywhere. But there is no time machine as yet available for any such brief excursion of the past.

We do have, however, the printed record of many of these meetings in our *Transactions* and a quick glance at one or two early volumes of the *Transactions* will suggest some of the changes that have been made in the intervening years. Volume one of the *Transactions* was published as part of the *Agricultural Report—1872—Kansas* and included brief summaries of the first five meetings of the Academy and a few papers. Included among these papers were catalogues of Kansas plants and of Kansas birds; analyses of Kansas coals and limestones; a report on the geology of the Arkansas Valley from Hutchinson to Fort Aubrey; and a review of Kansas climate for the five-year period 1868-72. Professors Carruth, Snow, Saunders and Mudge were the principal contributors to the volume.

Mudge's reference to Fort Aubrey in his report of Arkansas Valley geology is illuminating as Fort Aubrey, about four miles east of the present town of Syracuse, had been established as a military post for the protection of the Santa Fe Trail some half-dozen years before the publication of Mudge's paper. In fact, in 1872 Kansas was still largely eastern Kansas with a population of, roughly, one-fifth our present one. Snow's paper, too, on the climate of Kansas shows great changes in Kansas of 1872 and the present; for Snow's report was based on his observations alone at Lawrence. The only Federal meteorological records at that time were kept at Leavenworth, where the government had established a station in 1871. Mr. Flora's paper, reviewing Kansas weather for the past year and contained in this issue of the *Transactions*, is based on reports from some 250 observers over the state.

Most of these papers in our first volume, however, were but early prototypes of a form of paper which we still publish. The notable exception in content in volume one of the *Transactions* was a paper by Lizzie J. Williams of Kansas State College at Manhattan "What is Good for an

Artist, and What an Artist is Good For." It is an able plea for a broad and general education for a student aspiring to a career in art, together with an exposition of some of the applications of art; commercial art, we would call it at present. Miss Williams was far in advance of her day as art education in any form was virtually unknown in the United States in 1872.

The complete volume in our Number One—it was reprinted together with volumes two and three as a separate in 1896—contains 64 pages and no illustrations. Volume 51, 1948, of our *Transactions* contains 496 pages and well over 100 illustrations. We have, in the years since 1872, grown bulkier and more comprehensive if not better!

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication date, namely the fifteenth of March, June, September and December.

The 81st annual meeting of the Academy will be held at Manhattan, Kansas, on April 28, 29, and 30. Professor Karl Stacey of Kansas State College is chairman of the committee on local arrangements and a well worthwhile program and meeting is thereby assured.

The editor looks with some awe on the figure 81. He attended his first meeting, if his memory serves correctly, when the figure was 51. We can all be proud of the fact that our institution has reached the venerable age of 81 and has served the state with distinction during its life. May it continue its distinguished service.

Dr. O. P. Dellinger, for many years a member of the Academy and its president in 1921-22, is now Senator Dellinger, a member of the Kansas State Senate. We congratulate the Senator on his unselfish contribution to the State, not only as a member of the biology staff of Kansas State College, Pittsburg, for many years, but now also as a member of the State's highest governing body.

Dr. and Mrs. L. J. Gier of William Jewell College, Liberty, Mo., spent the Christmas holidays at the Field Museum in Chicago studying the mosses of Kansas and Missouri in the extensive collections of the museum.

Dr. Penrose S. Albright, chairman of the Academy research awards committeee has announced grants to Herman D. Smith and Charles Hess. Mr. Smith is studying the possibility of producing hybrids in gallinaceous birds at Kansas State College, Manhattan, and Mr. Smith is examining the possibility of use of certain Kansas plants for their antibiotic properties at McPherson College.

We announce with regret the death of two members of the Academy during the last quarter: Professor Robert B. Dunlevy and Dr. Edward G. Kelly.

Professor Dunlevy was one of our oldest members having joined the Academy in 1896. For 47 years he was professor of geology at Southwestern College, Winfield, joining

the Southwestern staff in 1895 after his graduation from the University of Wisconsin. He retired from active duty in 1942 but continued a consulting practice in petroleum geology. His death occurred in Winfield on Dec. 31, 1948.

Dr. Kelly, a member of the Academy since 1935, came to Kansas in 1907 as research entomologist for the Federal Bureau of Entomology at Wellington, a position which he held for eleven years. In 1918 he was employed by Kansas State College as extension entomologist, a position he held until his death. In this capacity he directed many state-wide campaigns for the control of Hessian fly, grasshoppers, chinch bugs, cutworms and many other insect pests. Dr. Kelly also took a very active part in the work of 4-H clubs and interested many boys and girls of these clubs in amateur entomology. In his death at Manhattan, Kansas, on Feb. 7, 1949, the state has lost a distinguished and useful servant.

Professor Gerald W. Tomanek, a member of the botany staff, Fort Hays Kansas State College, has been granted leave of absence beginning June 1, 1949. He plans to spend his leave at the University of Nebraska working on his doctorate and expects to return to Fort Hays in September, 1950.

Dr. Arthur W. Davidson, professor of chemistry at the University of Kansas, Lawrence, has been named associate editor of the *Journal of the American Chemical Society*. Dr. Davidson's term of office began with the current year.

Two former teachers of plant physiology in Kansas colleges attained the age of seventy years recently. Dr. Edwin C. Miller, former professor at Kansas State College, Manhattan, and now professor emeritus at that institution, reached this milestone on December 16, 1948. Dr. Miller, who is living at Wilmington, Ohio, is a life member of the Kansas Academy. Dr. Charles A. Shull, formerly professor of botany at the University of Kansas and now professor emeritus at the University of Chicago, was seventy years old on January 19, 1949. Dr. Shull, who now resides at Asheville, North Carolina, was a member of the Kansas Academy while teaching at Kansas.

Professor Lawrence Oncley, president of the Academy in 1936-7, has resigned his research position in the Snyder Research Foundation, Winfield, and is teaching science during the current semester at Far Brook School, Scotch Plains, New Jersey. Professor Oncley expects to return to Winfield in June.

Mr. Paul B. Gibson, a mid-year graduate of the University of Wichita, has joined the physics staff of that institution and will teach a course in electronics.

The Flint Hills Geology Club of Kansas State College, Emporia, has been active the past year. Among its activities have been field trips to the moraine on Highway 99 and to the "volcanic" outcrops northwest of Manhattan.

Extensive reports on the results of animal husbandry research projects under way at the Experiment Stations at Hays and at Manhattan will be given in detail at the annual Cattlemen's Round-Up at Hays on

April 30 and at Livestock Feeders' Day at Manhattan on May 7. Summaries of these reports may be expected in later issues of the *Transactions.*

Through the courtesy of Earl K. Nixon, geologist for the State Geological Survey, Lawrence, we give the statement below on mineral production in Kansas for the past three years. With the exception of the data for petroleum and petroleum products for 1948, all values for the last year are preliminary estimates. If any proof is needed that the mineral industry is important in the economy of Kansas, examination of the following table should provide that proof.

Kansas Mineral Production

	1946	1947	Est. 1948
Asphalt (native)			
Cement	$ 11,574,910	$ 13,017,277	$ 14,000,000
Chats		504,101	500,000
Clays:			
Products (other than pottery and refractories)	2,771,000		4,000,000
Raw (sold by producers)	283,350	376,961	400,000
Coal	7,473,000	9,153,910	9,000,000
Gypsum (crude)		Concealed, but included in "Misc."	
Lead	1,405,010	1,811,269	1,811,269
Mineral paints (zinc and lead pigments)			
Mineral waters			
Natural gas	55,760,000	62,400,000	68,680,000
Natural gasoline Liquefied petroleum gases	475,000	3,000,000	9,466,275
Ores (crude), etc.:			
Lead			
Zinc			
Zinc-lead			
Petroleum	138,800,000	200,080,434	279,527,443
Pumice		Concealed, but included in "Misc."	
Pyrites			
Salt	4,014,919	4,534,406	4,500,000
Sand and gravel	2,505,822	2,056,009	2,500,000
Stone	3,908,588	4,867,789	5,250,000
Zinc	11,639,532	7,641,709	6,000,000
Helium			
Miscellaneous	5,044,818	5,000,000	5,000,000
Total values, eliminating duplications	$245,655,949	$314,443,865	$410,634,987

Dr. W. M. Jardine, president of the University of Wichita for the past fifteen years, becomes president-emeritus on June 30, 1949. From 1918 to 1925, Dr. Jardine was president of Kansas State College, Manhattan. Dr. Jardine also served as U. S. Secretary of Agriculture under President Calvin Coolidge, and as U. S. Minister to Egypt under President Herbert Hoover.

Publications of the State Geological Survey, University of Kansas, Lawrence, announced since our last issue include:

Bulletin 74, *The Stratigraphy and Structural Development of the Salina Basin of Kansas,* Wallace Lee, Constance Leatherock, and Theodore Botinelly, 155 pages. Mailing charge, twenty-five cents.

Bulletin 75, *Oil and Gas Developments in Kansas during 1947,* W. A. Ver Wiebe, G. E. Abernathy, J. M. Jewett, and E. K. Nixon, 230 pages. Mailing charge, twenty-five cents.

Bulletin 76, *Ground-water Supplies at Hays, Victoria, Walker, Gorham, and Russell, Kansas,* Bruce F. Latta, 76 pages. Mailing charge, ten cents.

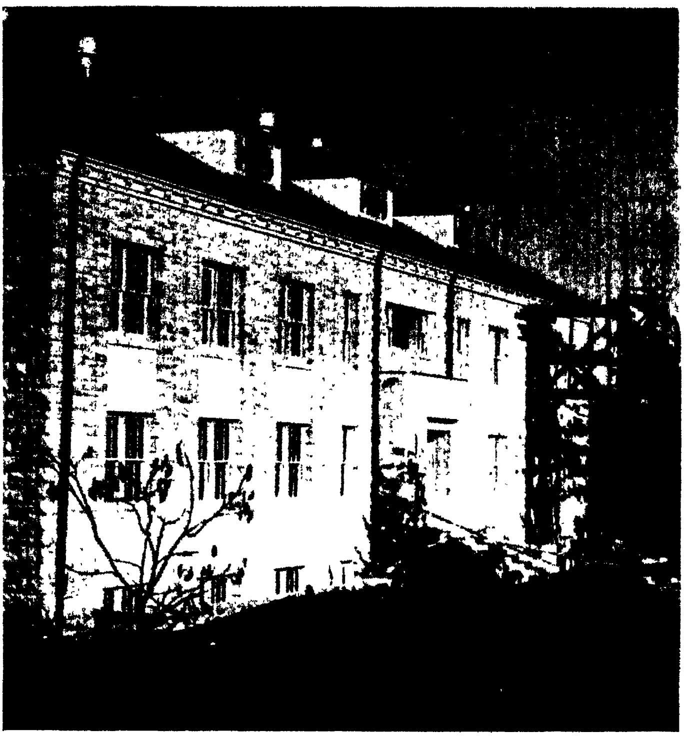
Bulletin 82, Part 1, *Chemical and Petrographic Studies of the Fort Hays Chalk in Kansas,* Russell T. Runnels and Ira M. Dubins, 36 pages. Mailing charge, ten cents.

Map, *The Petroleum Industry in Kansas,* Earl K. Nixon, 38 x 54 inches. Mailing charge, twenty-five cents.

The above publications can be secured by addressing the State Geological Survey for the mailing charge indicated.

Dr. D. B. Sharp of the department of chemistry, Kansas State College, Manhattan, is directing two research projects, one of which is financed in part by the Research Corporation of America and the second by the Office of Naval Research. The first project is a study of the mechanism of reactions of vicinal tricarbonyl compounds and the second, in co-operation with the department of physics, is the investigation of the mechanism of reaction of molecular oxygen with various organic compounds.

A modern small-animal laboratory is rapidly approaching completion at Kansas State College, Manhattan. The new laboratory, erected at a cost of $200,000, will replace one lost by fire in 1941. The building will be ready for occupancy about April first, and will house projects in animal experimentation under way in the departments of zoology, chemistry, animal husbandry, home economics, and bacteriology. Academy members present at the spring meeting will be interested in inspecting this modern animal laboratory.



A Study of Spotted and Fallowed Wheat Fields In West Central Kansas

BYRON O. BLAIR, FRED W. ALBERTSON and HAROLD S. CHOGUILL
Fort Hays Kansas State College, Hays, Kansas

Introduction

During the spring of 1947, spotted growth areas appeared in many wheat fields in west central Kansas. Such spots had been noted prior to 1947 when the weather was favorable. Seasonal conditions most favorable for such growth are drought in late summer and early fall, followed by ideal growing conditions in late fall and winter. This produces ample vegetation for pasturing of wheat by livestock.

The major causes of spotted wheat fields in the past 25 years have been studied by the Kansas Agricultural Experiment Stations[1] particularly in those areas of the state where rainfall is relatively light. Research by Lipman[2] and others revealed a great deal about nitrogen supply and deficiency but little about calcium and phosphorus of the soil and their relationship to the grain produced on fallowed fields, and those continuously cropped containing small areas of taller dark green wheat.

The areas selected for study were on a farm four miles north of Hays, Kansas, and the project was conducted with the cooperation of the farm operator, Mr. J. D. Fellers. Two fields were chosen for study: "A", a continuously cropped field (Fig. 1) and "B", a fallowed field adjacent to Field "A" (Fig. 2). Both of the areas had been farmed by Mr. Fellers and as far as could be determined, the two fields were comparable as to soil type, topography and erosion.

Field "A" (the continuously cropped area) had been in wheat since 1943. In both fields, the seedbed had been prepared by moldboard plowing, spring-toothing to pack the soil and kill volunteer wheat, and harrowing to level the soil just before seeding. Stubble burning had not been practiced in either field. Fields "A" and "B" were seeded to Comanche wheat, September 20, 1946. Thirty-four pounds of wheat per acre were used in seeding each field. When wheat pasture was available, both fields had been grazed heavily by a dairy herd during the three years previous to this study.

Further reference to the areas studied will be given by the symbols: "G" for the green spots in the continuously cropped area,

"Y" for the yellowish areas adjacent to the green spots of field "A", and "F" for the fallowed areas of field "B".

Growing conditions were ideal during the last forty-five days

Figure I. The Continuously Cropped Area.

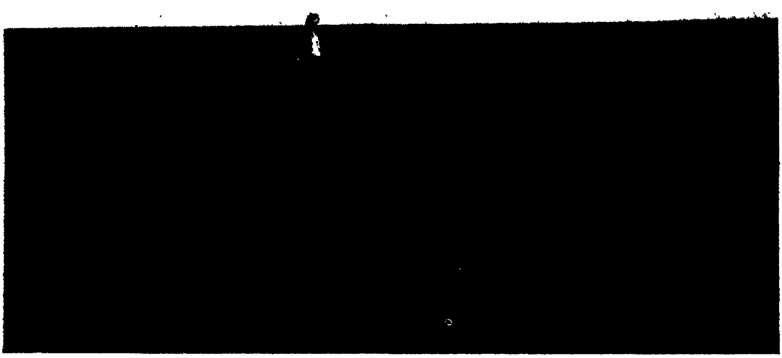


Figure II. The Fallowed Area.

of growth. The soil moisture during this period remained above thirteen per cent in the upper five feet, and about twenty per cent in the upper two feet (Table I). Probably the high moisture content of the surface soil on the fallowed area is partially a result of the

heavy vegetation which prevented evaporation. Temperatures were moderate with an average of 71.8° F. which was 1.8° below the average mean for this period[3]. The comparative heights of the plants, when the problem started May 21, were 19, 28, and 36 inches, respectively, for "Y", "G", and "F" areas (Table II). At maturity their heights were 32, 40, and 46 inches, respectively. The "Y", "G", and "F" areas produced 80, 138, and 152 stalks per yard in the row and 64, 108, and 120 mature heads per yard which is similar to the results of Roemer[4]. The rows were 10 inches apart, averaging 19 rows per rod.

Table I. Per cent Soil Moisture Per Foot to a Depth of Five Feet on Continuously Cropped and Fallowed Areas.

Depth in Inches	May 21	June 4	June 25
	Continuously Cropped Yellow Area		
1-12	24.60	30.00	23.30
12-24	21.60	28.50	20.50
24-36	18.20	17.75	21.00
36-48	14.60	15.50	15.10
48-60	14.98	17.30	14.10
	Continuously Cropped Green Spots		
1-12	24.02	19.70	22.40
12-24	20.88	18.00	19.70
24-36	16.05	15.80	16.10
36-48	15.56	14.60	14.30
48-60	17.48	14.50	13.90
	Fallowed Area		
1-12	25.76	25.50	30.80
12-24	14.50	15.50	27.00
24-36	23.56	15.41	25.60
36-48	12.42	13.75	18.10
48-60	13.46	14.10	14.50

Table II. Ecological Data of Continuously Cropped and Fallowed Areas.

	Yellow Area	Green Spots	Fallow
Height of plants May 21 in inches	19	28	36
Height at maturity in inches	32	40	46
Number of stalks per yard	80	138	152
Number of heads per yard	64	108	120
Number of rows per rod	19	19	19
Distance rows apart in inches	10	10	10
Pounds seeded per acre	34	34	34
Number of leaves per plant	3	3	4
Width of leaves in inches	.33	.43	.43
Length of leaves in inches	4.75	5.75	7
Number of tillers per plant	3	4.2	6.8
Length of head in inches	1.75	2.25	2.25
Number of kernels per head	16.6	21.5	21.0
Number of kernels per mesh	2	2	2
Date harvested	July 2	July 2	July 4
Yield in grams of 200 heads	106.4	154.7	133.7
Computed yield in bushels	17.2	50.1	49.2
Amount harvested in bushels	17.5		36.5
Test weight in pounds per bushel	63	64	62
Hail damage in per cent	13.5	13.5	5

The "F" area produced slightly over twice as many tillers as did plants on the "Y" area. Plants on the "F" and "G" areas were not only taller and more abundant but also had a greater leaf surface than the fewer plants on "Y" area. Leaf surfaces were 16 sq. in., 24 sq. in. and 31 sq. in., respectively, for the "Y", "G", and "F" areas which represents a ratio of 1 to 1.5 to 2. The length of the mature

heads varied from 1.75 inches on "Y" area to 2.25 inches on both "G" and "F" areas having two kernels per mesh which produced an average of 16.6, 21.5, and 21 kernels per head respectively for the three areas "Y", "G", and "F". Hand threshing of two hundred heads yielded 106.4 gms., 154.7 gms. and 133.7 gms. which produced a calculated yield of 18, 51.9, and 49.2 bu. per acre after hail damage had been deducted. Fields "A" and "B" were harvested on July 2, 3, and 4, and the yield from the "Y"-"G" area combined was 17.5 bu. and from the "F" area, 36.5 bu.

Chemical Analysis

The cores of soil previously removed for soil moisture determination were analyzed for total calcium, available calcium, phosphorus, nitrogen, and organic matter. The hand threshed grain was analyzed from protein, calcium, and phosphorus. Analysis for nitrogen and total calcium was conducted according to procedure given by Method of Analysis of the Association of Official Agriculture Analysis[5], available calcium by Morgan method[6], phosphorus by the Troug method[7], and organic matter by procedures given by Emerson[7]. The protein and calcium determinations of the grain were made by procedure given by A.O.A.C. and phosphorus by S. C. Piper[8].

The soil on the "F" area was higher in organic matter and nitrogen content than the "G" or "Y" area (Table III). The upper foot of the "G" area was higher in nitrogen, and at all depths was slightly higher in organic matter than "Y" area. The increase in nitrogen in the upper foot of area "G" appeared to be caused primarily by urine from the cattle which had grazed the wheat. In a few instances the spots could have been caused by manure from previous years since the field had been pastured by a dairy herd when wheat growth was available prior to 1946. It is not likely that any of the spots would be caused by manure of the current year unless it was worked into the soil by trampling to hasten decomposition.

Analysis for total calcium revealed that the soils of this area are high in calcium oxide content. The presence of a calcium carbonate layer between 24-36 inches, below the surface is noted readily from the concentrations of calcium carbonate found at this level. The fallowed area which was higher in moisture content during the period of study was lower in calcium at the surface level and higher at levels below three feet than found in the "G" and "Y" areas. This is an indication of the leaching of calcium from the surface to lower levels in fallowed fields.

Table III. Results of Analyses of Soil and Grain on Continuously Cropped and Fallowed Areas.

SOIL

Depth inches	Organic Matter	Per cent Nitrogen	CaO	Available CaO	P_2O_5
		Field "A"—Yellow Area			
0- 6	5.10	.123	3.28	.30	.099
6-12	5.25	.110	3.56	.36	.094
12-24	5.20	.085	3.49	.42	.101
24-36	5.68	.064	6.53	1.12	.130
36-48	4.96	.045	6.33	.92	.141
48-60	4.63	.044	4.77	.72	.147
		Field "A"—Green Spots			
0- 6	5.35	.129	3.45	.30	.094
6-12	5.62	.126	3.61	.38	.101
12-24	5.82	.086	4.05	.43	.104
24-36	6.20	.064	6.52	1.13	.145
36-48	5.08	.042	5.04	.89	.151
48-60	4.97	.044	5.41	.62	.153
		Field "B"—Fallow			
0- 6	6.10	.163	3.21	.34	.108
6-12	5.82	.166	3.69	.40	.104
12-24	6.86	.145	3.60	.36	.103
24-36	6.38	.108	6.67	1.07	.127
36-48	5.71	.046	5.73	.95	.156
48-60	5.15	.045	5.68	1.04	.156

WHEAT GRAIN

Per Cent

Protein	Calcium	Phosphorus
	Field "A"—Yellow Area	
11.82	.070	.375
	Field "A"—Green Spots	
12.37	.081	.450
	Field "B"—Fallow	
11.21	.076	.469

Approximately ten per cent of total calcium oxide present was found available for plant use. Slightly more calcium was found available in area "F" than in "G" or "Y". This was most likely the result of more moisture and time for decomposition of vegetative residue with consequent production of quantities of carbonic acid which when acting upon calcium oxide makes more calcium available. The presence of more available calcium at greater depths in the area "F" may be accounted for by leaching of more total calcium to those depths, and also it may be in part due to lack of uniformity of the soil sampling. The lack of phosphorus in the carbonate layer region may in part be explained in that plant roots have difficulty penetrating that region and only the more vigorous roots succeed. This limits root formation in that area. After passing through the carbonate layer the roots again branch forming more root residue. Root residues from past crops make more total phosphorus in those areas below the calcium carbonate layer.

The protein content of the wheat produced on area "F" was less than wheat produced on "G" by 1.12 per cent and .57 per cent less on area "Y". Although the protein content was lower than either of the other areas, the fallowed area provided enough reserve moisture and nitrogen to produce twice the tillers, leaf surface per

plant, and yield per acre than area "Y" produced. The calcium content of the grain grown on all the areas in question was very high as compared to other recent analyses. The grain from area "G" contained slightly more calcium than the other areas.

The phosphorus content was much more uniform containing amounts comparable to samples recently analyzed[9]. Grain from area "F" contained slightly more phosphorus than either of the other areas which may be due to the presence of slightly more phosphorus in the soil.

Summary and Conclusions

From the information obtained in this study, the following conclusions are in evidence. Nitrogen content of the soil appears to be the major factor in production of green spots of wheat. This nitrogen is probably the result of urine residues in pastured fields. In the fields studied, the amounts of phosphorus and calcium of the soil were adequate, so that variations of growth and color were not due to deficiencies of these elements.

Continuously cropped areas during seasons of scanty rainfall tend to develop nitrogen deficiencies. Grain produced on green spotted areas tends to be higher in calcium, phosphorus and protein. The yield and test weight per bushel are also higher than grain produced on the nitrogen deficient areas adjacent to the spots. Fallowed land yielded more forage and more grain of high calcium and phosphorus content than did the "Y" continuously cropped areas.

In the locality investigated, a calcium carbonate layer at a depth of 24 to 36 inches provided from two to three times the amount of available calcium found in the top soil. As a result, the wheat of the west central Kansas area shows a very high content of calcium.

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The Relationship of Certain Descriptive Factors To Hypnotizability

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The purpose of this paper is to present some suggestive findings relevant to the role of certain descriptive factors, such as age, sex, and psychiatric diagnosis, in hypnotizability. The findings to be offered are the impressions gained from examining data accumulated as part of a general research project into the psychiatric applications of hypnosis at the Menninger Foundation.*

The original population comprising this study, and the one from which most of our impressions are derived, consisted of 447 psychiatric patients seen at the Menninger Clinic. It was thought worth while to be able to compare the over-all hypnotizability of this population with other groups of subjects, varying in degree of maladjustment. Four other groups were added to the original: a group of 270 patients (psychiatric and non-psychiatric) from a nearby Veterans Administration hospital; 75 psychiatric residents in training at the Menninger Foundation School of Psychiatry; 26 employees of the Menninger Foundation; and a mixed group of 79 subjects including mostly sophomore medical students, plus a variety of professional persons.

The procedure followed in all cases was to conduct group hypnosis sessions, with basically the same suggestions used for all sessions. The detailed procedure actually did vary somewhat, but not markedly. The lack of complete standardization of procedure and of precise definition of criteria was due primarily to the fact that most of the data were accumulated for purposes other than the specific study of hypnotizability. Only light trance hypnosis, as usually defined, was attempted. In this study it was decided that any subject who carried out successfully either the handclasping or the eye closure test, would be considered hypnotizable; subjects who carried out neither one of those suggestions were considered for our purpose, not hypnotizable.

Our most general findings are the following:

1. That the sex of the subject is not a significant determinant

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*This project was at the time of writing, under the direction of Drs. Margaret Brenman and Merton M. Gill of the Menninger Foundation, sponsored by the Josiah Macy, Jr., Hofheimer, the Menninger Foundations, and by the Division of Research Grants of the United States Public Health Service.

of hypnotizability. This finding, based upon our original patient population is in agreement with the statements of most investigators of hypnosis.

2. That age *per se,* is not a reliable criterion of susceptibility to hypnosis, and that advanced age, for example, does not preclude achieving the hypnotic state. On the other hand, our data indicate that younger adults, for example below 26, tend to show greater hypnotizability than do adults above that age, thus allowing the possibility that the factor of age may contribute to hypnotizability when other variables are also considered.

3. That the sex of the hypnotist is not important; two equally experienced hypnotists, one male and one female, obtained the same results in terms of the percentages of their subjects who achieved light trance hypnosis. It appears also that while very experienced operators obtain better results than do very inexperienced operators, there is a relatively early point beyond which success in group hypnosis does not increase with increasing experience.

4. That there appears to be some relationship between the presence or absence of maladjustment and hypnotizability, subject, however, to many qualifications at this time. Our data show a striking difference between the hypnotizability of the patients as a group and the subjects comprising the student and employee groups. The patient population included only 19.% light trance subjects, while the latter groups contained approximately 44.% light trance subjects. This discrepancy confirms one's daily impressions from working with patients and non-patients in group hypnosis sessions. However, it appears that absence of psychiatric illness *per se,* is not a sufficient indication of greater hypnotizability. The group of psychiatric residents responded very much the same as the patient population, with 20.% light trance subjects. In addition to the qualification that some subjects lacking marked maladjustment features may be as poor hypnotic subjects as are psychiatric patients, our data also indicate that many good subjects can be found among persons with serious emotional disturbance. This is most clearly seen among the patients diagnosed hysteria, 40.% of whom achieved light trance. The response among the hysterics is interesting both for the question it raises regarding the relationship of maladjustment to hypnotizability, and for what light it may throw upon the old question of the relation of hysteria to hypnotizability. The 40.% figure compares favorably with the hypnotizability of our student-employee group, and is twice that of any other specific diagnostic group. The data

suggest that hysterics may prove to be somewhat more hypnotizable as a group than other psychiatric conditions. It is also to be noted, however, despite this trend, that 60.% of the hysterics remained unhypnotizable. Our impression at this time is that while there appear to be some factors among maladjusted persons which tend to interfere with hypnotizability, and there appear to be some factors among hysterics making for their greater susceptibility as compared with other psychiatric subjects, certain specific determinants of hypnotizability remain undiscovered, in the setting of which the effect of presence or absence of maladjustment may be more clearly seen.

5. That degree of maladjustment, within the pathological range, does not appear directly related to hypnotizability. This can be inferred from the data if the usual criterion of the presence of a psychosis is accepted as the greatest degree of maladjustment. Contrary to general belief, the data indicate that psychosis *per se,* does not preclude or even lessen susceptibility, at least not to any greater extent than does a psychoneurosis or a character disorder. Among the subjects in the patient population, the schizophrenics responded as well as a group as did the psychoneurotics and the character disorders. It is suggested once again that the differences in hypnotizability are to be explained on the basis of specific factors not as yet partialled out.

The general findings reported above need to be verified by a much more rigorous investigation under controlled, standardized conditions, with adequate statistical evaluation, before they may be considered more than suggestive. However, it is the writer's feeling that the results of the most carefully conducted mass study of descriptive factors, just as the findings reported here, would not provide answers to the bewildering question of hypnotizability, but would serve primarily to point out areas for further investigation. To the extent that the direction of future research may be seen more clearly through mass investigations, such studies are needed and worth while. As an attempt to achieve any direct understanding of hypnotizability, however, such an approach appears to be a misguided effort. If, for example, it were to be confirmed under ideal conditions for mass investigations, that hysterics are better hypnotic subjects as a group than are other psychiatric subjects, it would be an "interesting" datum, but one would still have to know why it is so, and also why some hysterics are poor subjects.

It would appear that a more fruitful approach to the problem of

susceptibility to hypnosis would be a consideration of individual dynamic factors, rather than mass descriptive factors. Such an approach, which would emphasize intensive clinical investigation of relatively few cases at a time, would stem from the hypothesis that the hypnotic situation is primarily an interpersonal relationship, in which the subject's characteristic mode of relating to others is involved. It would attempt to demonstrate that hypnotizability is somehow related to personality structure, and more specifically would seek to discover what needs are important for the subject's adjustment, and to what extent he is able to accept those needs and gratify them. Beginning steps to investigate the dynamic factors in hypnotizability have been reported by White, by Rosenzweig, and by Schafer in an unpublished study. Many questions arise which might guide the investigator of dynamic factors. What is the relation of passivity to hypnotizability? Is the most overtly passive person the best subject, or is the person with strong underlying passive needs just as hypnotizable? Does rigorous denial of passive needs preclude hypnotizability? Is the person who characteristically employs repression as a defense mechanism particularly suspectible? Are rigid and compulsive individuals poorer subjects? What factors in the make-up of the subject account for changes in his hypnotizability from one day to the next? The answers to such questions would tell us a great deal about hypnotizability. They can only be obtained through intensive clinical investigation of the individual subjects.

Some Noteworthy Records of Amphibians in Texas

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For the past decade the senior author has accumulated herpetological material from various parts of the state of Texas. Preparation for intensive study of the amphibians, by the senior author, has led to the discovery of a number of noteworthy items in the collection, herein reported in part. All specimens were collected by Mr. and Mrs. Ottys Sanders, and are at present in their personal collection.

Desmognathus fuscus brimleyorum Stejneger

A single specimen (No. 549) is from Votaw, Hardin Co., secured May 1, 1938. As recorded, the range of this race is greatly extended by the present specimen, which comes from more than 200 miles south of the southernmost area previously included, in extreme northeastern Texas. This is moreover perhaps the first specimen collected in the southern portion of its range, although numerous other specimens from scattered localities have been secured by residents and collectors in the area. It is expected that other students will clarify the range of the race in Texas in the near future.

Desmognathus fuscus auriculatus (Holbrook)

A single specimen (No. 550) is from Votaw, Hardin Co., May 1, 1938. It has the heavily pigmented belly characteristic of the race, and constitutes the first record of this race in Texas. If it were the only specimen known to us from this area, we would entertain considerable doubt as to the propriety of its present allocation. Other collectors have secured specimens also, however, and these will be recorded elsewhere. It is of interest that the present individual is perhaps the first to have been collected in the state.

The anomalous citation of two races in one locality (*D. f. auriculatus* and *D. f. brimleyorum*) we can justify with the supposition that they occupy different ecological niches. Further exploration is necessary to demonstrate whether the ranges of the forms actually overlap, or the forms intergrade, in the questioned area. The taxonomy of *D. f. brimleyorum* is seriously involved, since an overlapping of its range (however improbable) with that of *D. f. auriculatus* may require, at least by one view, that the form be regarded as a distinct species, as it obviously cannot intergrade elsewhere with the same or other races of the species *D. fuscus*.

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Plethodon cinereus serratus Grobman

A single specimen (No. 556) was collected May 5, 1940, at Fern Lake near Nacogdoches, Nacogdoches Co. It constitutes the first record for the state and extends the known range of the species southward about 200 miles from the Ouachita Mountains of Arkansas and the Kiamichis of Oklahoma.

Single or a series of but few specimens representing peripheral localities seldom can be racially assigned with complete assurance, especially if the locality lies within a different biotic area, and if the races have been precisely defined. The present specimen is no exception. It has a moderately narrow dorsal band (about 50% body width), but the chief character of *P. c. serratus*—the serrate lateral edge of the median band—is not evident. The anterior portion is very slightly serrate on one side, but elsewhere the edges of the median stripe are virtually straight. The stripe is fully as serrate in typical *P. c. cinereus.* If it were not highly improbable, geographically, that the specimen represented *P. c. cinereus,* we would place it with that race. Since however *P. c. serratus* is the race most reasonably represented, of those now recognized, and since our sample is totally inadequate to give an idea of the characteristics of the local population, we tentatively assign the specimen to the subspecies *P. c. serratus.*

Ecological Comparisons of Three Genera of Moles

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The three types of mole herein discussed, mainly from the ecological standpoint, occupy roughly: a) genus *Scalopus,* the Atlantic and the Gulf slopes of the United States; b) genus *Scapanus,* the humid parts of the Pacific coastal region; and c) genus *Talpa,* the British Isles. Our knowledge of the two American genera is based largely on personal field studies over most parts of their respective ranges, East, West, and Middlewest, through a period of years[7-11]. We gathered the English mole lore mainly from the generous and well-illustrated writing of Barret-Hamilton, in his "A History of British Mammals"[1], with wider ramblings through other fields of English natural history dealing with fact or fancy. European mole lore trails back to the days of King Arthur, and must be sifted for separation of the two in the sieve of modern research.

As a first comparison, the habits and relations to enviroment of the English mole are more like those of our northwestern Pacific coast moles than they are those of the more proximate Atlantic coast genus; or of the latter two genera like each other. This would seem to indicate parallel development of *Talpa* and *Scapanus* in similar climates, influenced largely by the Gulf Stream and the Japanese Current, respectively. This like adaptability of faunal forms in the two regions, through time, is reflected also in the response of floral types when interchanged in recent farm and garden practice. Extension north and south of our long Pacific coast line has given the taxonomist warrant for distinguishing three species of mole in the genus *Scapanus*[8]. But we are little concerned here with the anatomical differences. England-Scotland-Wales has but one species, *Talpa europea*[1]. Ireland has no moles[5]. There are only subspecific differences among our eastern moles of the genus considered here, throughout its range[3]. The species is *Scalopus acquaticus,* though why *"aquaticus"* concerns only Linnaeus, who so named it.

All moles are burrowing mammals, active in all seasons at shallow depths in the soil. Their senses of smell, touch, and hearing are highly developed, perhaps the more acutely in the order here given, with the latter two connoting soil vibration stimuli. The sense of sight has become nearly useless in the enviroment of their subterranean existence and the vestigial organs of vision do not ordin-

arilly function. But here, as a first premise, the English mole[1] and the Pacific coast mole (Fig. 1) seem to have an advantage—if an advantage—over the mole of eastern America. An anatomical study

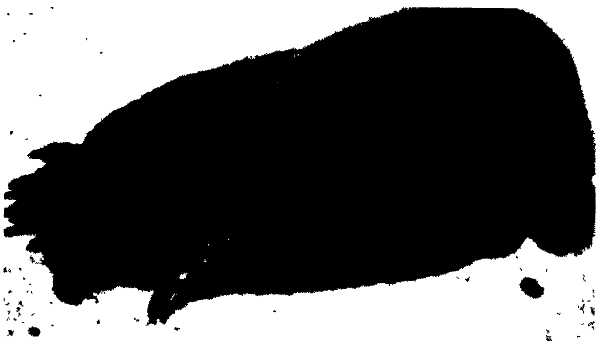

Fig. 1. The Townsend mole (Scapanus townsendi) of our Northwest Pacific coast. Eye not so large as it appears to be; bare skin encircles the tiny eyeball. Biological Survey photo by Theo. H. Scheffer.

indicates that *Scalopus* can at best detect the difference between light and darkness through a membrane having no eye-slits[6]. *Talpa,* of the British Isles, and *Scapanus,* of the Pacific Coast, can, on the other hand, radiate and flatten the fur of the eye region and protrude a tiny eyeball. This they do when disturbed or annoyed in captivity. In the rare instances when they forage above ground in the moonlight, or when they "boil" out of the shallow runs fighting, as they occasionally do by day, these vestigial eyes probably function, though dimly.

Where a mole "hangs his hat" and calls the place home is a matter of individual choice, and opportunity to find a sheltered nook with a fairly dry roof of sod, soil, wood, or whatever. For the race is not social and seems to have no habits related to the good of the community. In this country, a ridge or knoll, a fence row, a stump, serves the mole for location of a shelter-nest. The nursery-nests here are apparently of temporary construction, sometimes of grasses only partly dried, and usually just under a thick roof of sod, where warmth of the April sun will penetrate. There is no superimposed mound or hillock of any sort, as figured in the English

illustrations[1]. These nurseries, in our Pacific-Northwest coast country, may be discovered in open pastures and meadows by prodding about with the heel or a shovel handle where radial lines of mole-hills converge on a bit of higher ground. (Fig. 5). Shelter nests as well as nurseries are connected with the deeper runways of the burrow system and these, in turn, with the shallow hunting paths that upridge the surface.

The English mole, if we are to fully credit all the descriptions and illustrations available, shows some departure from our Pacific genus, *Scapanus*, in the construction of its habitations, even to differing plans in the runway systems of the male and the female,

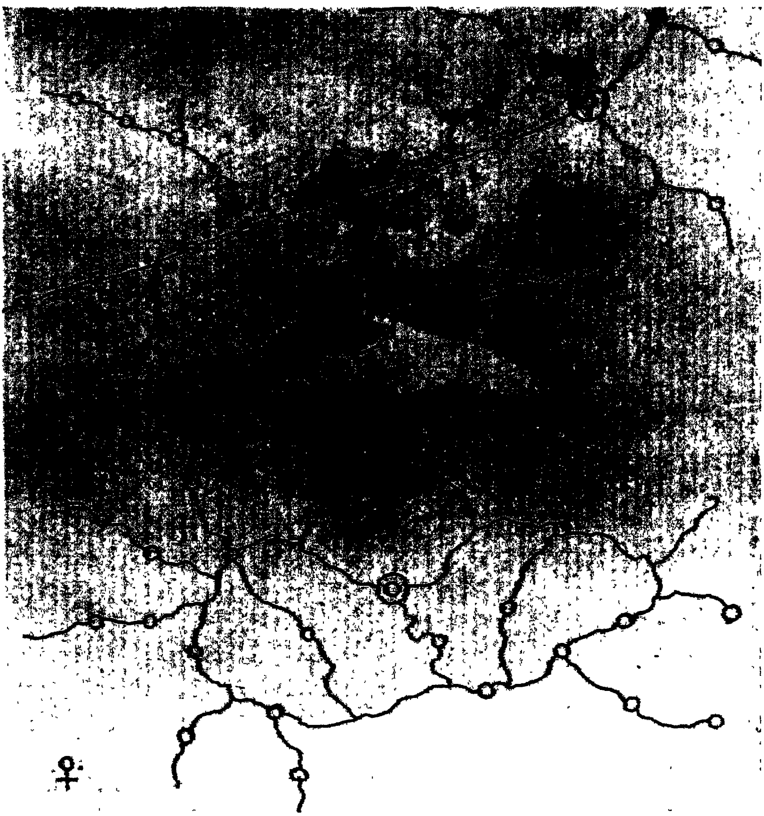

FIG. 2.—ENCAMPMENT OF MOLE. ♂ male, ♀ female, (O) fortress, tunnels.

Fig. 2 This diagram from Barrett-Hamilton's "A History of British Mammals" is self explanatory We can discover no such distinction between male and female runway systems in this country. Illustration used here by permission of the publishers, Gurney & Jackson, London.

respectively (Fig. 2). Over there, too, the nest seems to be sheltered usually under a large mound, domed and "copped towards heaven" (Shakespeare). This is designated as a "fortress" (Fig. 3,4) and is perhaps the traditional "molehill" of which we sometimes "make a mountain". It is evidently a sturdy thatch and defense for a low-ground situation and is commonly about a yard in diameter and at least a foot in height. The nest beneath may be entered by one or

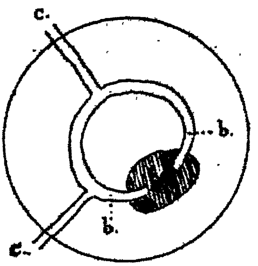

FIG. 3.—PLAN OF TUNNELS OF SIMPLE FORTRESS. See also Fig. 4.

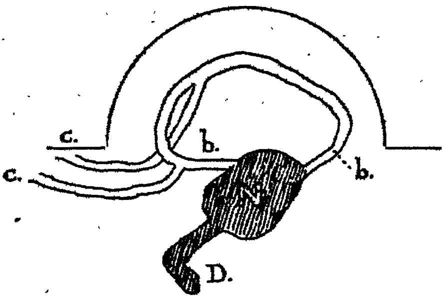

FIG. 4.—SECTION OF SIMPLE FORTRESS, plan which is shown in Fig. 3.

Figures 3, 4. This diagram of the fortress of an English mole, in vertical and cross sections, shows outline of the super-imposed dome. This feature is also indicated in several other, more complicated diagrams of Barrett-Hamilton's "A History of British Mammals". Illustration used here by permission of the publishers, Gurney & Jackson, London.

more horizontal runs and has, in addition, a "bolt-run" or escape (perhaps drainage) tunnel leading steeply down, to return sometimes to the near-surface a little distance away. Nests of the American species are not necessarily, nor usually, under a *mole-hill,* which is here, and is so differentiated in Britain, but a heap of soil thrust up for disposal incident to tunnel excavations. The *fortress* is something different, as indicated above, and the *bolt-run* we cannot interpret by any comparable structure here. It sometimes ends deep down and blindly (Fig. 4, D).

The earlier English naturalists credit their mole with more engineering science than we can discover in the American genera[1]. A blueprint pattern followed by moles in designing their runway systems is too far-fetched for universal credit. More evidentally these patterns are as diversified as the lay of the land and the character of the soil may require, where construction is undertaken at whims of the individual mole. Of course there is some basic uniformity throughout the group, particularly in modus of digging and disposal of the excavated earth. Such disposal, aside from the mere

upridging of the surface soil or sod, follows one or the other of two patterns: the mole-hill pattern, more common with *Scapanus* or the mole-ridge pattern generally followed by *Scalopus*. In the latter type of construction the loose earth is pushed through a near-surface tunnel and crowded laterally so as to spread its walls (Fig. 6). This process may greatly broaden the initial sub-surface ridge and, at the same time, retain the original passageway. It is a long, loose dump in lighter type of soils. A mole-hill is built up, by contrast, as a volcanic cone, by upthrusts through the center of the dome, the material rolling down the slopes. Numerous and conspicuous mounds of this sort dot the Pacific coast landscape locally (Fig. 7) and similar mole-hills appear on the English countryside[1]. In contrast, our eastern moles

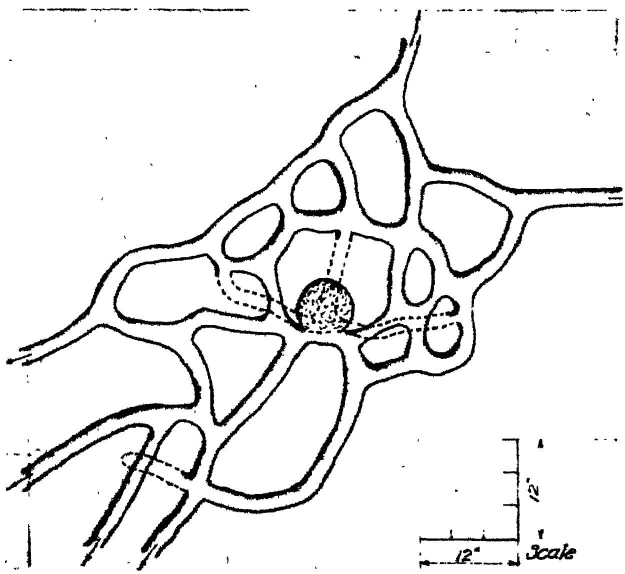

Fig. 5. Nursery nest and local runways of the Townsend mole (broken line course underneath the others and the nest). This is just one pattern of many, incidental to local conditions. There was no protective fortress nor other molehile above this diagram.

in this country (*Scalopus*) seldom cast up conspicuous mounds but more commonly resort to the mole-ridge plan of earth disposal.

Use of the same deeper highways of the mole by two or more to many of their kind is not uncommon, as observed here and reported from Britain[1,5]. With the Pacific coast genus such communal though not social use of highways seems to be general where the species abounds to the extent that runs of individuals must fre-

quently intersect. The proof of this is in the trapping of a score or more of moles at the same spot in the course of a season, something not at all unusual. And mole runways in this country, coast to coast, are everywhere frequented by trespassing small rodents, as well as the mole's cousins, the shrews. Such intrusion is not definitely reported for Britain. Unfriendly encounters of mole and mole are known to occur at times, particularly in the breeding season. But there is no reason to assume the once popular belief, reported in England, that on all such meetings in traffic lanes one mole must retreat or provoke a fight to the death[1]. More likely they avoid hostile encounter and go about their business of hunting worms, for our observation and credited reports of conflict are rare. Moreover

Figure 6. Upridged burrow of the eastern mole, genus Scapolus, broadened in places by extrusion of excavated earth through its walls. This genus does not commonly build conspicuous mole hills. Biological Survey photo by Theo. H. Scheffer.

there are many side roads to take, and a mole is so coupled that he may double back at almost any place in his runway.

The mole is a little beast of prey, catching its food alive and eating it forthwith [1, 4, 5, 7, 11, 13, 14]. The national dish with all three genera under discussion here is earthworms. In addition, the mole consumes other small living tenants of the soil—particularly insects and their larvae and pupae, spiders, centipedes and the like. Being quite voracious in their appetites, moles must be upon the hunting paths much of the time. This we have confirmed by check-

ing the traffic in their runways at all hours of the day and night[8]. We have seen no indications in this country that they store for the rainless day, though that is a mooted subject with British naturalists[1, 5]. From the accumulated evidence, we doubt much the storing propensity or habit. There has been too much irrelevant analogy—like wasps storing spiders—and little or no scientific investigation.

The proportion of insect diet to that of earthworm consumption is considerably greater with our eastern genus, *Scalopus,* as compared to *Scapanus* of the Pacific coast. This is largely a matter of relative availability. In the British Isles the relative proportions

Fig. 7. Mole hills of the genus Scapanus in gravelly soil of the Pacific Northwest. Such hills are common and conspicuous in the humid sections of this region. Biological Survey photo by Theo. H. Scheffer.

of insect diet to earthworm-diet will run between the two extremes of the American genera[1, 5]. The shallower burrowing of our eastern moles, with corresponding absence of earth mounds seem to reflect the greater search for insects in the teeming upper layers of the soil.

The mole is a slow breeder, bringing forth the young but once a year and in small numbers at that. In respect to fecundity the three genera differ but little. A large number of checks of pregnant females indicates that the commoner number of young in the case of the Pacific coast mole is three[11, 14]; with the eastern mole, four[7,8]

The average litter of the English mole is reported as between three and four [1, 5]. This relatively low fecundity of the mole race should be correlated with the comparative safety of the animals, underground, and the fact that they are not relished by larger predators—bird or beast.

With respect to utilization of moleskin in the fur trade the English have long had the advantage, though they do not seem to have followed it up in more recent years. Their advantage came through the supply of skins provided by the professional mole-catchers, who earned thus a pittance in addition to the bounties paid by land owners[1]. America has imported as many as three or four million skins a year when milady nodded to the fashion[11]. In 1940-41 the British Board of Trade called for ten million mole skins for export, the response to which we have not been able to learn. But it is presumed that drafting the younger trappers for the military service may have greatly reduced the take of moles. We had a flurry on the moleskin market in this country shortly after World War I, when the trade paid 50-60 cents apiece for Pacific coast mole[5]. But later cooperation with the sole processors of such skins—in New York—failed for lack of interest in the profits.

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The Ecology of a Pasture in the Dakota Sandstone Formation in Ellsworth County, Kansas*

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INTRODUCTION

The vast area of prairie of the United States has long been known as the "feeding grounds" for herbivorous animals. In the past, the standard of living of the people of grassland regions has been measured largely by the ability of the native ranges to produce vegetation sufficient to maintain economical livestock production. It has become apparent that if our desired living standard is to be maintained, we must direct our efforts toward a program by the most rapid and efficient means possible, which will bring economic stability to the seventeen million acres of grassland in the Great Plains region.

Need for improving and conserving the grassland, the nation's meat basket, has brought forth much information on pasture management; yet more practical data are in great demand. Maximum livestock gains can be secured only if the pastures are maintained at high economical production. This can not be accomplished without a knowledge of the problems at hand, and as far as possible, their solution.

Forage production in the Great Plains varies greatly with topography, climatic factors, and soil types. Soil types appear to have a decided bearing upon the value of vegetation produced. If the problems of production, maintenance, utilization, etc., on different soil types are to be solved, research on comparable locations must be undertaken.

Many pastures have become infested with annual grasses which have caused the operators to become concerned. It is possible, however, that many of the owners have not learned the true value nor the control of these invaders.

The previously mentioned problems are common in pastures of the Dakota Sandstone Formation. This thesis is a report of the study of basal cover, composition, yields, consumption, and chemical composition of the vegetation on an average pasture in the Dakota Sandstone Formation of central Kansas. It is the hope of the author that this information will prove beneficial both to the land owners and to the conservationist.

RELATED STUDIES

Few investigations have been made relative to utilization of grasses with respect to consumption, chemical composition, and gains made by

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livestock. Some of the recent investigations have been carried on at Woodward, Oklahoma; (Savage and Heller, 1947,) and at Moccasin, Montana (Williams and Post, 1945). These studies were conducted to determine periods of greatest gains of livestock in relation to chemical composition of the forage consumed. 'At both stations water, protein and fat content declined as the season progressed. High protein and rapid gains up to June 30 at both stations indicate that early seasonal utilization is desirable.

Studies by Weaver and Albertson (1940) were made in Western Kansas, Nebraska, portions of Wyoming, Colorado, and the Panhandle of Oklahoma to determine the deterioration of the grassland of the mid-west plains. Basal cover of grasses was found to have been reduced to twenty-one per cent in better pastures, and to as little as one per cent in poorer pastures.

In a study of the mixed prairie near Hays, Albertson (1937) divided the grazing areas into three types. These three areas were big bluestem dominating the lowland, little bluestem and the midgrasses more common on hillsides areas, and the short grasses which occupy the hilltops and level lands. The grouping of dominants in these areas was first recognized as plant associations by Clements (1920).

Frequent droughts undoubtedly affect plant associations which remain visible many seasons after they occur. Albertson and Weaver (1942) made a study of the native vegetation of Western Kansas during seven years of extreme drought. Many of the mesic plants were found to have disappeared and the more xeric plants reduced in number. Comparatively few taxonomic surveys have been made in the counties of western Kansas. Darland (1936) observed the plant life about Tasco lake in Sheridan county where xerophytic, mesophytic, and hydrophytic plants were abundant. Publications by Gates (1936, 1940, 1941). Rydberg (1932), and Hitchcock (1935) were helpful in identifying plants in the area studied.

Research by Darland and Weaver (1945) on different pasture types of east-central Nebraska indicates that much of the total seasonal production occurs early in the season. Much early production results from cool weather grasses and annual downy brome.

Studies made of shortgrass pastures subjected to different intensities of grazing indicate that moderately grazed areas produce the most grass, and enough litter and debris to prevent soil erosion (Tomanek, 1948).

Maintenance and fattening requirements vary with different classes of livestock and few investigators are in complete agreement on these requirements. Feeding standards by Morrison (1946) have been accepted

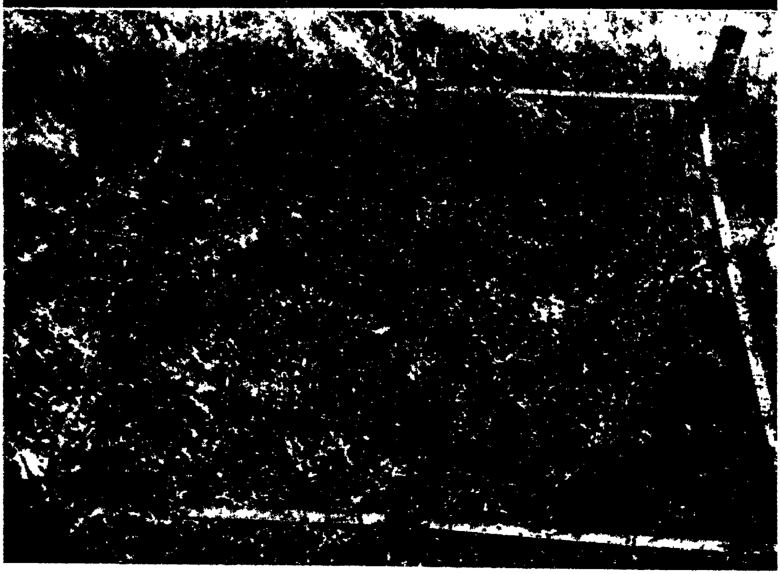


Fig. 1. General view of pasture showing midgrass in foreground and outcrops of Dakota Sandstone and spring-seeps on slopes of ravine in distance.

Fig. 2. A view of the shortgrass area. Note wild alfalfa and wavy leaved thistle in the foreground.

Fig. 3. Meter quadrat in little bluestem type.

in this study as the correct guide for feeding requirements. Stoddard and Smith (1943) quote other authorities as to nutritional needs of range animals.

HISTORY AND DESCRIPTION OF AREA STUDIED

The area studied was a part of the South Half, Section 21, Township 17, Range 7, of Ellsworth county, Kansas, which is located approximately in the geographic center of the state. The pasture, a sandstone prairie, is typical of about 2,350,000 acres of strongly dissected plains which extend south and westward from the south-central Nebraska line to a point above the Arkansas flood plain of central Rice county. The elevation at this point is 1470 feet. In 1935 the area supported 469,000 head of cattle (Mann, 1936). The area is drained by the Republican, Solomon, Saline and Smoky Hill river systems which cross from west to east. Some of the state's most productive soils are found in these valleys. The uplands, however, are too steep, rough and broken for cultivation. Prominent surface rocks are brownish-yellow, medium-fine-grained sandstone, inter-bedded with heavy clay shales of the Dakota series. Annual precipitation ranges from 24″ to 29″ and the mean temperature varies from 53 to 56 degrees F. (Fly. 1905). The pasture selected for study was typical of those found in the Dakota Sandstone Formation, having irregular terrain, Rocky outcrops, and spring fed streams (Figure 1).

The pasture studied is believed to be a part of the original 38,000 acre "Idavale Ranch" acquired (1878-1884) by Captain James Millet. In 1894 following a recession of the cattle market the ranch sold to a firm in the east (Streeter, 1946). Under new ownership M. M. Sherman, a native Texan, became the operator and continued to serve in that capacity until the mid-1930's. All the grassland, except outlying small areas, was lightly to moderately grazed (eight acres per animal unit). Many smaller pastures under separate lease and comparable to the area studied, however, were grazed very heavily particularly during the drought of 1932-1935. In 1937, the pasture was purchased by E. D. Blair, who was the owner at the time the study was conducted. During the years 1937-1946, the pasture was moderately grazed (five acres per animal unit) for the five-month grazing season and usually deferred the remaining seven months. Intense grazing during the early period of drought (1932-1935) was quite evident in that all habitats were severely infested with Japanese brome (*Bromus japonicus*) which gained entrance from the adjacent tilled fields during the dry years. The principal forage producing species of grass before the drought was big bluestem (*Andropogon furcatus*). It has remained the dominant species in the lowlands and on other more mesic locations. During the years 1940-1946 this species invaded the north-

facing slopes and extended beyond the midgrass habitat into the outer margins of the areas dominated by short grasses.

METHOD OF STUDY

Representative areas in each of the shortgrass, midgrass and tallgrass habitats in the pasture were selected and protected from grazing by exclosures for the entire growing season of 1946. Ten quadrats, each a meter square, were laid out inside the shortgrass experimental area, and twelve plots were selected inside each of the midgrass and tallgrass exclosures. Since cover and composition of vegetation have a direct relationship to the value of a pasture, all quadrats were charted at the beginning of the season and the per cent basal cover was later computed by the use of a planimeter. The average cover of all quadrats in each exclosure was assumed to be representative for each habitat. The acreage of each habitat was determined by the line transect method which is later described in more detail.

Forb counts over an area of a 6-foot circle were made at 42 stations at intervals of 250 feet along 10 line transects. There were 17, 19, and 6 stations respectively in the shortgrass, midgrass, and tallgrass habitats.

The line transect method also was used in determining the utilization of grasses each month. These transects were run at intervals of 150 yards, and a total of 450 stations over the 195.5 acre area were measured. As previously mentioned the number of stations of each grassland type encountered along these transects was used in calculating the number of acres in each habitat.

At the end of each month clippings were made of grasses, weeds, and forbs on representative quadrats in each exclosure. The monthly clippings were air-dried and weighed to obtain forage production in ponds per acre of a grazed pasture. The remaining quadrats were clipped at the end of the season to determine yields if the pasture had not been grazed.

By observation and the use of monthly utilization records, it was possible to determine the vegetation most desired by the cattle. In order to estimate the nutritive value of the vegetation consumed, clippings of about 40 grams of each of the key species were made each month. These samples were quick-killed at 104 F. for 30 minutes and preserved in glass jars (Loomis and Shull, 1937). The analyses served as a means of determining the amount of water, protein, calcium, phosphorus, and fat that the cattle were consuming monthly. Such records enabled the writer to evaluate the annual as well as the perennial grasses.

Environmental conditions were obtained from the United States

Weather Bureau monthly reports, and by the use of rain gauge which was centrally located in the pasture. The rainfall and temperatures were computed monthly and compared with the average mean for each respective month during the growing season. Soil moistures to a depth of 60 inches were determined once each month during the study period by the use of a geotome.

On May 2, 1946, 54 head of cattle which represented an average of 42 animal units (Grazing Land Management—MD 66, United States Department of Agriculture) were turned into the pasture. The weight of each animal was estimated by the author, and the owner of the livestock when they were turned into the pasture. Included in the herd were 11 dry cows, 5 short yearlings, and 1 bull. The remainder of the herd was composed of 16 cows with calves by their sides, and 5 cows that would calve about May 20.

Notes were taken during the period of study on the grazing activity of the cattle, period of most rapid gains, and the effect of environmental conditions upon the production of vegetation.

RESULTS

Environmental Conditions

Environmental conditions in this area during the growing season of 1946 were the most adverse since 1939. The mean temperature in May was 4.7 degrees below normal as a result of many cloudy days (Table 1). Mean temperatures during June, July, and August, however, were 2.2, 2.3, and 2.4 degrees, respectively, above normal. September temperatures were 1.5 degrees below normal.

Precipitation during this period was more than 7.45 inches below normal. Rainfall for May was 1.46 inches below normal in spite of the existing cloudy weather. The drought continued through June, July, and August when the deficits were respectively, 2.73, 1.75, and 1.78 inches. September precipitation of 2.97 inches was .27 inches above normal.

Cover and Composition

The upland or shortgrass habitat (Figure 2) comprised a total of 77.4 acres. Basal cover of grasses in this habitat was 88.4 per cent (Table 2). Buffalo grass (*Buchloe dactyloides*), the dominant species made up a mat cover of 82.4 per cent which was interspersed with 6 per cent of blue grama (*Bouteloua gracilis*), (Figure 3, Table 2). The soil in this habitat was a heavy black silty clay loam 10 to 14 inches deep which caps a light gray to white subsoil. Small granular rocks were prevalent in many areas below 48 inches. Grasses on these areas, although sufficient in cover to

Table I. Temperature and rainfall for the growing season of 1946 at Geneseo, Kansas.

TEMPERATURE
(Degrees F)

Month	May	June	July	Aug.	Sept.
Mean 1946	59.7	77.2	83.1	79.9	69.5
Normal Mean	64.4	75.0	80.8	77.5	71.0
Deviation	—4.7	+2.2	+2.3	+2.4	—1.5

RAINFALL

Inches per Month	2.49	1.42	.95	1.54	2.97
Normal	3.95	4.15	2.70	3.32	2.70
Deviation	—1.46	—2.73	—1.75	—1.78	.27

Table II. Per cent basal cover of grasses and number of acres in each habitat of the area studied.

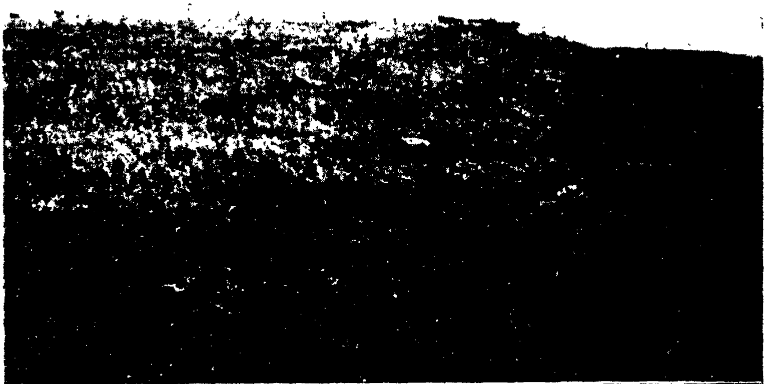
Species	Habitat		
	Shortgrass	Midgrass	Tallgrass
Buffalo grass			
Blue Grama	6.0	.. ..	. ..
Big Bluestem	.... ..	2.8	8.2
Little Bluestem	.... ..	12.7	6.0
All others	.... ..	1.7	2.6
Total Basal Cover	88.4	17.2	16.8
Acres	77.4	89.5	28.9

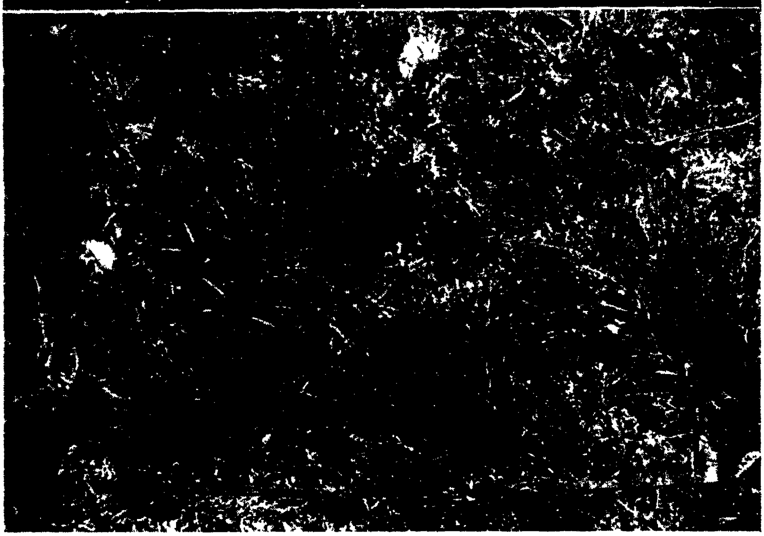
prevent erosion, become dormant very early, during dry seasons, consequently in 1946, they began to enter dormancy in mid-June.

The midgrass habitat of 89.5 acres (Figure 4) which made up about 46 per cent of the total area of the pasture had a basal cover of 17.2 per cent (Figure 5).

Little bluestem (*Andropogon scoparius*) with 12.7 per cent cover and big bluestem (*Andropogon furcatus*) with 2.8 per cent, comprised most of the grass cover on this habitat. Other less important species with 1.7 per cent cover were side-oats grama (*Bouteloua curtipendula*), switch grass (*Panicum virgatum*), Scribner's panic grass (*Panicum scribnerianum*), Indian grass (*Sorghastrum nutans*), and a grass-like *Eleocharis-Juncus* complex of *Eleocharis obtusa* and *Juncus macer* (*J. tenuis*).

The steep slopes with light sandy loam soils of this habitat are subject to severe sheet erosion. A light brown sandy loam soil covers the rocky reddish clay subsoil 8 to 12 inches. Partially weathered sandstone is usually encountered within 20 inches of the surface. Although very permeable, these areas are low in calcium, phosphorus, and organic matter (Fly, 1946); therefore, they have a low water storage capacity. Outcrops of yellow, brown, and red sandstone provide outlets in many places for shallow surface water. Marshy springs develop on the steeper slopes where the soils are shallow. These areas are dominated by a dense cover of sedges and rushes. Vegetation on such areas remained succulent and provided high-protein forage during the season when vegetation on other areas was dormant. Water piped from such areas into tanks and ponds was adequate for the livestock.





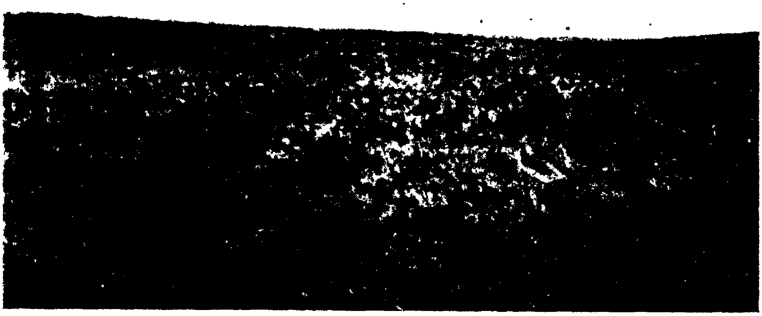


Fig. 4. A view of the little bluestem habitat showing forbs and typical sandstone outcrop.

Fig. 5. Typical quadrat in little bluestem type.

Fig. 6. General view of the big bluestem area. Tall forbs in the background are ironweed.

The remaining area of approximately 29 acres constituted the tallgrass habitat with a cover of 16.8 per cent (Figure 6). Big bluestem was the most abundant species of grass in this area with a cover of 8.2 per cent. The little bluestem cover was 6 per cent and the remaining 2.6 per cent was made up of less important species, most important of which were prairie cord grass (*Spartina pectinata*), side-oats grama, Indian grass, and switch grass. Japanese brome was especially abundant in this area (Figure 7). Soils in this habitat were very productive, which is characteristic of the heavy black loam, 16 to 20 inches deep, which caps a lighter sandy loam subsoil. The water holding capacity is much greater than in the lighter soils on the slopes. Variations in precipitation causes the height of the

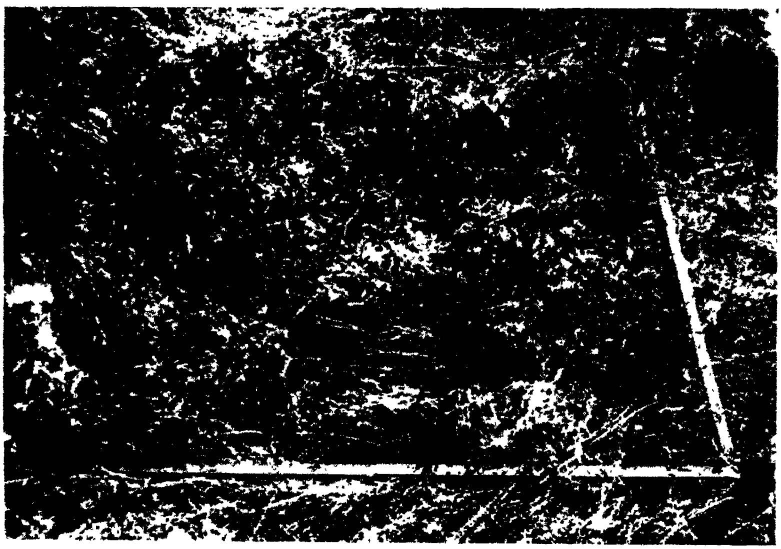


Fig. 7. Perennial grasses overtopped by Japanese brome.

water table to vary; but unless the seasons are unusually dry, it is probable that the roots of most perennial forbs and grasses penetrate to the water table. Although the carrying capacity of these grasslands is higher than that of the areas westward, it is not as high as in the flint hill region to the east. Correct management is important as much of this grassland has been subjected to damage by misuse.

Soil Moisture

Soil moisture at the 1-3-5- foot levels was computed. During the first month it was sufficient at all depths in each habitat to produce rapid growth (Table 3). Rainfall during early June was below normal, consequently, the heavy growth of Japanese brome used much of the

moisture reserves. As the drought continued in July, the grasses and forbs in the shortgrass habitat became dormant. The deeply rooted species of grasses and forbs in the midgrass and tallgrass habitats continued growth despite the very dry top soil where there occurred only 5 and 7 per cent soil moisture. Precipitation in July and August was very limited, and during the latter month soil moisture at a depth of five feet was reduced to a point where water was doubtless unavailable to plants. At this time total moisture was 10.5, 5, and 7.3 per cent, respectively, at three foot levels in the shortgrass, midgrass, and tallgrass areas. Growth of grasses was negligible in the shortgrass area during July and August; also, many of the shallowly rooted species in the midgrass and tallgrass areas became dormant. Big bluestem and little bluestem, however, continued to grow in the more mesic areas. The drought was broken in early September when rainfall was sufficiant to increase soil moisture to 8.8, 5.6, and 5.6 respectively, in the surface foot of shortgrass, midgrass, and tallgrass habitats. Shortgrasses renewed growth and both species flowered, but seed development failed due to an early frost.

Table III. Approximate percentages of soil moisture to depth of 60 inches in the three habitats during the growing season. 1946.

Inches	Habitat	May	June	July	Aug.	Sept.
0-12	Shortgrass	19.7	18.7	7.1	5.2	8.8
	Midgrass	15.8	12.6	5.1	4.0	5.6
	Tallgrass	10.5	9.4	7.0	4.9	5.6
24-36	Short grass	18.4	14.3	15.2	10.5	11.1
	Midgrass	12.4	9.2	12.7	5.0	5.6
	Tallgrass	11.0	13.0	11.3	7.3	6.0
48-60	Shortgrass	18.4	13.5	18.0	11.2	13.5
	Midgrass	12.9	12.9	10.8	rock	6.0
	Tallgrass	20.2	16.2	18.1	12.1	10.9

Forb Counts

Forb counts made early in June along the line transects indicated that the most forbs occurred in the more mesic midgrass habitat, where an average of 88.7 forbs per 6-foot circle was found at each of the 19 stations, (Table 4). In the tallgrass habitat the average was only 39.7 forbs at each of the 6 stations and on the most xeric shortgrass habitat it was further reduced to 36.2 at the 17 stations.

The wavy leaved thistle (*Cirsium undulatum*), although not the most abundant in total numbers, was present at a greater number of stations than any other species. It was found at 76 per cent of the stations being more numerous in the tallgrass habitat. (Table 3). Many seedlings counted in June, died later in the season due to drought. Wild alfalfa (*Psoralea tenuiflora*), the most important legume, was second in abundance occurring at 66.6 per cent of the stations. It was most frequently found in the midgrass habitat where an average of 3.6 plants per station was

observed. Perennial ragweed (*Ambrosia psilostachya*), was noted at 60 percent of the stations and was most abundant in the tallgrass and midgrass habitats. Many of the seedlings of this species, as was noted in regard to the thistle, died later in the season when the drought became acute. Prairie sage (*Artemisia gnaphalodes*), and (*A. ludoviciana*), occurred respectively, at 38.8 and 26 per cent of the stations. Even though it occurred at a small per cent of the stations, the number of plants was

Table IV. Average number of individuals of forbs in six-foot circles in each habitat and percentage of circles in which each species was found.

Species	Average number of individuals in a 6-ft. circle Habitat			Occurrences
	Short	Mid.	Tall	Percentage of circle
Cirsium undulatum	4.6	3.6	7.7	76.0
Psoralea tenuiflora	2.4	3.6	1.5	66.6
Ambrosia psilostachya	9.7	17.9	22.3	59.5
Artemisia gnaphalodes	8.2	12.5	6.0	38.8
Artemisia ludoviciana	4.1	3.9	1.3	26.0
Plantago purshii	4.9	36.2	.0	38.0
Oxalis stricta	.6	1.9	.7	35.7
Callirrhoe involucrata	.1	.6	.2	19.0
Opuntia macrorrhiza	.2	.4	.0	19.0
Meriolix serrulata	.7	.7	.0	16.5
Hymenopappus corymbosus	.4	.4	.0	14.2
Erigeron ramosus	.0	1.3	.0	9.5
Tradescantia bracteosa	3.	5.2	.0	7.1
Total	36.2	88.7	39.7	

relatively large at each location where it was found. Midgrass areas were most seriously infested with Pursh's plantain (*Plantago purshii*), a small plant thriving on sunny slopes. Its presence in great numbers on thin outcrops accounted for the high total forb count in the midgrass habitat. Wood sorrel (*Oxalis stricta*), although not of great importance, was found generally throughout the pasture being observed at 35.7 per cent of the stations; it was most abundant in the midgrass area, where an average of 1.9 plants per station was noted. The remaining forbs observed included purple poppy mallow (*Callirrhoe involucrata*), prickly pear cactus (*Opuntia macrorrhiza*), evening primrose (*Meriolix serrulata*), Hymenopappus (*Hymenopappus corymbosus*), daisy fleabane (*Erigeron ramosus*), and spiderwort (*Tradescantia bracteosa*). These species were found at scattered stations but were not significantly abundant.

Seasonal Yields

Grass production on the areas clipped monthly was 1,000 pounds per acre on the short grass, 760 on the midgrass, and 1,020 pounds on the tallgrass habitats (Figure 8). Yields on similar plots in the same areas harvested at the end of the season were, in the same order, 1,125; 710, and 1,170 pounds per acre.

Weed production, mostly Japanese brome, was very high on all

three habitats. Yields on areas clipped monthly were 950 pounds per acre in the shortgrass, 925 pounds in midgrass, and 1,925 pounds per acre in the tallgrass habitats. Seasonal weed yields were only 290, 230, and 190

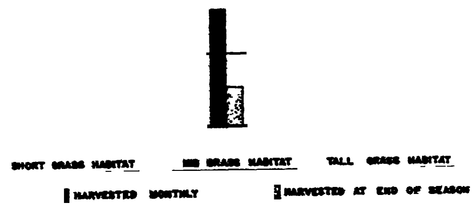


Fig. 8. Seasonal and monthly yields of grasses, weeds and forbs.

pounds per acre, respectively, for the three habitats. This was doubtless due to the fact that much of the Japanese brome, which contributed to the high monthly yields, had disintegrated by early fall when the seasonal harvests were made.

Forb yields on the three areas harvested monthly were 40 pounds, 100 pounds, and 130 pounds per acre. Due to the drought many forbs, especially in the shortgrass area, did not grow after the first monthly clipping, consequently the yields were negligible.

Monthly Yields

Production of grasses in the shortgrass habitat was greatest before June with a yield of 720 pounds per acre (Figure 9). This was followed by a rapid decline during June, July, and August when only 115 pounds per acre were produced for the 3 months. Fall moisture stimulated growth during September when the acre yield on the shortgrass type was 165 pounds, making a total of 1000 pounds per acre for the season. Growth of grasses on the midgrass area was much slower than in the shortgrasses, but it was more continuous through the season with a production of 145, 135, 65, and 165 pounds per acre, respectively, in June, July, August, and September, and a total of 760 pounds per acre for the season.

Grasses in the lowland also grew much slower during early spring than did the shortgrass; also, production continued during the season similar to that in the midgrass habitat. Production on this type in June, July, August, and September, in that order, was 240, 60, 160, and 230 pounds per acre. This made a total of 1,020 pounds per acre for the season.

Yields of grasses for the entire pasture during May was 89,753 pounds (Table 5). This represented a production of 55,875 pounds on the shortgrass area, 24,702 pounds on the midgrass area, and 9,176 pounds on the tallgrass area. Total yields declined sharply in June to 9,350; 12,998; and 6,825 pounds respectively, on the shortgrass, midgrass and

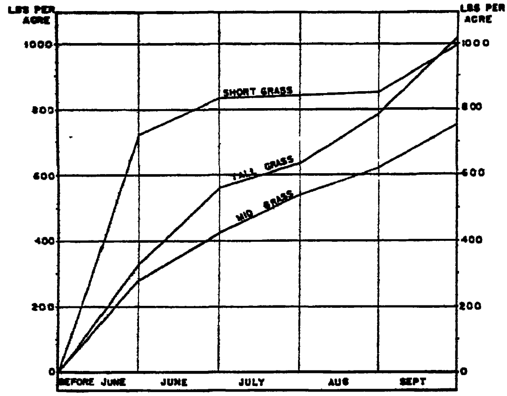


Fig. 9. Growth rate and cumulative yields of grasses.

tallgrass areas, making a total production of 28,982 pounds. July production in the same sequence as above declined even greater to 952, 10,310,

Table V. Yield in pounds of perennial grasses and BROMUS on shortgrass, midgrass and tallgrass habitats during May, June, and July, 1946.

Habitat	Grass	May	June	July
Shortgrass	Perennial grasses	55,875.0	9,350.0	952.0
	Bromus	58,321.0		
Midgrass	Perennial grasses	24,702.0	12,998.0	10,310.0
	Bromus	62,355.0		
Tallgrass	Perennial grasses	9,176.0	6,825.0	2,569.0
	Bromus	52,413.0		
Total	Perennial grasses	89,753.0	28,982.0	13,831.0
	Bromus	173,089.0		

and 2,569 pounds for a total of 13,831 pounds. Japanese brome was of considerable importance to total forage production. Yields in May were, respectively, 58,321, 62,355, and 52,413 pounds for the three areas. This represents a total of 173,089 pounds produced during May—nearly twice the yield of perennial grasses.

Chemical Constituents

The water, protein, and fat content of grasses sampled showed the same general trend as did the yields, decreasing from a high in early May to a low in August (Table 6).

Table VI. Percentage of water, protein, calcium, phosphorus, and fat of principal grasses during period of grazing, 1946.

	Species	May	June	July	Aug.
Water	Japanese brome	68.3	24.6	.... ..	.... ..
	Big bluestem	68.3	27.8	37.6	18.0
	Little bluestem	. .. ..	.... ..	23.2	15.1
	Plains B. grass	68.7	21.3	27.4	.... ..
	Short grasses	.... ..	.... ..	22.4	15.2
Protein	Japanese brome	16.45	9.67	....	....
	Big bluestem	14.72	11.65	9.64	8.75
	Little bluestem	....	....	8.84	6.64
	Plains B. grass	11.68	8.46	14.00	.. ....
	Short grasses	....	....	8.28	6.74
Calcium	Japanese brome	.33	.27	....	....
	Big bluestem	.29	.31	.42	.37
	Little bluestem	....	....	.32	.45
	Plains B. grass	.28	.27	.46	....
	Short grasses	....	....	.35	.34
Phosphorus	Japanese brome	.24	.16	....	....
	Big bluestem	....	.26	.31	.14
	Little bluestem	....	....	.19	.10
	Plains B. grass	.16	.22	.26	....
	Short grasses	....	....	.16	.14
Fat	Japanese brome	3.6	2.1	....	....
	Big bluestem	3.4	2.4	2.3	2.1
	Little bluestem	....	....	2.3	1.9
	Plains B. grass	3.2	2.7	3.0	.... . .
	Short grasses	....	....	2.1	2.0

The water content of the three species, Japanese brome, big bluestem, and plains blue grass was slightly over 68 per cent during May. It dropped to an average of 24.7 per cent in June but both species increased in water content in July. Both big bluestem and plains bluegrass increased in water content in July due to new growth on the areas grazed by livestock. Drought in August forced much of the grass into dormancy, decreasing the water content to the lows of the season of 18, 15.1, and 15.2 per cent water, respectively, in big bluestem, little bluestem, and the shortgrasses.

Japanese brome had the highest protein content (16.45 per cent) of all species in May. The abundance of this high-protein annual, undoubtedly, makes it more valuable than most livestock producers realize. Following the Japanese brome were big bluestem with 14.72 per cent, and plains blue grass with 11.68 per cent protein. In June the protein of Japanese brome dropped to 9.67 per cent as it approached maturity, while big bluestem decreased only to 11.65 per cent and plains bluegrass to 8.46. July forage, except in plains blue grass, experienced a further decline in protein. In big bluestem, the per cent dropped to 9.64 and in the succulent plains blue grass taken from hillside seeps, it increased to 14.00 per cent. Little bluestem and the short grasses were analyzed for the first time in July. Protein content of these grasses was 8.84 and 8.28 per cent, respectively. Protein in August dropped to 8.75, 6.64, and 6.74 per cent respectively, for big bluestem, little bluestem, and the short grasses.

Calcium content of Japanese brome of .33, big bluestem of .29, and

plains blue grass of .28 per cent in May, .27, .31, and .27 per cent in June. The percentage of calcium in July increased slightly as did the water content. For big bluestem, little bluestem, plains blue grass, and the short grasses, it was respectively, .42, 32, .46, and .35 per cent. In August it dropped to .37 and .34 per cent in big bluestem and the short grasses; but in little bluestem, it increased to .45 per cent.

The phosphorus content of plants increased during May, June, and July followed by a sharp decline in August. In May it was .24 and .16 per cent for Japanese brome and plains blue grass. In June the former species contained only .16 per cent and the latter increased to .22 per cent, but big bluestem was highest in phosphorus of all the species in June with .26 per cent. Increases continued in July to .31 per cent for big bluestem and to .26 per cent for plains blue grass; little bluestem and the short grasses contained .19 and .16 per cent respectively. During August big bluestem decreased to .14, little bluestem to .10 and the short-grasses to .14 per cent.

The fat content in Japanese brome, big bluestem, and plains blue grass decreased from a high in May of 3.6, 3.4 and 3.2 respectively to 2.1, 2.4, and 2.7 per cent in June. Decrease continued in July to 2.3 in big bluestem but it increased in plains blue grass to 3. per cent. For little bluestem, it was 2.3 and for the short grasses, 2.1 per cent. The fat content in August decreased to lows for the season of 2.1 for big bluestem, 1.9 for little bluestem and 2. per cent for the short grasses.

Utilization

Per cent utilization of total grasses produced during each month of the 90-day grazing period was 17.48 for May, 16.62 for June, and 24.20 for July (Table 7). The utilization of each species in May was 22.7, 20.3, 55.8 and 16.8, and 8.5 per cent, respectively, for Japanese brome, big bluestem, plains blue grass, the short grasses, and all other grasses. The per cent of stations (frequency) at which each species was found along the transects, in the same order as above was 22.6, 17.5, 2.2, 31.4 and 26.3 per cent. The proportional part that each species contributed to total utilization (col. 1 x col. 2 in Table 7) was 5.14 per cent for Japanese brome, 3.57 for big bluestem, 1.25 for plains blue grass, 5.28 for the short grasses, and 2.24 per cent for all other species. From the above data it can be seen that although plains blue grass was used 55.8 per cent, its proportional part (1.25 per cent) of the total consumption (17.5 per cent) was small because it was found so infrequently at the stations examined.

In June big bluestem was utilized 34.0 per cent, plains blue grass 52.8 per cent, the short grasses 9.6, and all other species 11.8 per cent. The frequency that these species were encountered, in the same order, was 21.5,

2.9, 47.0, and 27.6 per cent. Proportional per cent utilization, therefore, was 7.3, 1.52, 4.53, and 3.27 per cent, respectively, for big bluestem, plains

Table VII. Per cent utilization of grasses during May, June, and July, 1946.

Species	Per cent utilization of each species	Frequency*	Average** utilization
	(Col. 1.)	(Col. 2.)	(Col. 3.)
	May		
Japanese brome	22.7	22.6	5.14
Big bluestem	20.3	17.5	3.57
Plains B. grass	55.8	2.2	1.25
Short grasses	16.8	31.4	5.28
All others	8.5	26.3	2.24
		total	17.48
	June		
Big bluestem	34.0	21.5	7.30
Plains B. Grass	52.8	2.9	1.52
Short grasses	9.6	47.0	4.53
All others	11.8	27.6	3.27
		total	16.62
	July		
Big bluestem	35.2	26.4	9.29
Little bluestem	29.6	7.2	2.12
Switch grass	36.8	4.5	1.66
Short grasses	21.0	46.0	9.37
All others	15.9	11.1	1.76
		total	24.20

*the per cent of stations at which each species was found.
**the per cent that the utilized portion of each species, is of the grass produced.

blue grass, the short grasses, and all other species. This represents a total consumption of 16.62 per cent for the month.

Utilization in July was 35.2 per cent for big bluestem, 29.6 for the little bluestem, 36.8 for switch grass, 21.0 for the short grasses, and 15.9 for all other species. These species in the same sequence were found at a frequency of 26.4, 7.2, 4.5, 46.0, and 11.1 per cent of the total stations which represents an average utilization for these species in the above order of 9.29, 2.12, 1.66, 9.37, and 1.76 per cent for a total of 24.20 in July.

Nutritive Value of Vegetation Consumed

The amount of grass consumed by the 42 animal units during May was 19,942 pounds as compared to 17,982 in June and 25,488 pounds in July (Table 8). This represented a daily consumption of 15.8, 14.2, and 20.2 pounds per animal unit of dry grass, during May, June, and July. The average per cent protein content of the forage consumed was 13.07 in May, 10.93 in June, and 7.7 in July. Digestible protein is believed to be about two-thirds that of the total protein (Savage and Heller, 1947). Therefore, the amount of digestible protein consumed daily was 1.43, 1.07, and 1.15 pounds for May, June, and July which was adequate for maintenance and growth in May, and probably enough in June and July (Morrison, 1946).

Calcium in the grasses furnished 38.7 grams per day per animal unit in May, 28.2 in June, and 50.7 in July, which was sufficient for all classes of livestock (Stoddart and Smith, 1943).

Table VIII. Summary table given principal results of study of entire area.

	May	June	July
Perennial grass yield	89,753.	28,982.	18,831.
Japanese brome yield	173,089.	---- ------ ----	---- ------ ----
Per cent utilization	17.58	16.62	24.56
Pounds of grass consumed	19,942.	17,982.	25,448.
Animal units	42.	42.	42.
Pounds consumption per unit per day	15.8	14.2	20.2
Per cent protein	13.07	10.93	7.70
Pounds of digestible protein consumed per unit	1.43	1.07	1.15
Grams of calcium consumed daily per animal unit	38.7	28.2	50.7
Grams of Phosphorus consumed daily per animal unit	25.1	24.2	31.7
Weight of herd	31,980	---- ------ ----	41,690
Weight per animal unit	761	---- ------ ----	989
Net gain per animal unit	------ ------ ----	---- ------ ----	227
Net gain per animal unit per day	------ ------ ----	---- ------ ----	2.52

Grass consumed in May, June, and July provided 25.1, 24.2, and 31.7 grams of phosphorus per animal unit daily. These amounts are believed to be sufficient for growth and fattening.

The total estimated weight of the 42 animal units was 31,980 pounds, when the cattle entered the pasture on May 2. This represented an average weight of 761 pounds per animal unit. At the end of the season, 34 of the animals were weighed, the remainder again estimated. Total weight of the 42 animal units was 41,690 pounds—an average of 989 pounds per animal unit or a gain of 227 pounds for the 90-day period. The average daily gain per animal unit was 2.52 pounds. Most rapid gains were made by dry cows during the early grazing season.

Summary

The pasture under consideration was typical of those found in the Dakota Sandstone Formation. Irregular terrain, rocky outcrops, and spring-fed streams were features of the prairie. Three habitats representative of the three grass types, shortgrass, midgrass, and tallgrass were studied.

Midsummer droughts are not uncommon in the sandstone formation of central Kansas. The drought during June, July, and August of 1946, however, was more severe than usually experienced. Below normal rainfall and above normal temperatures limited grass production in all habitats. The shortgrasses became dormant soon after the heavy crop of Japanese brome matured.

Soil moisture deficiencies were apparent to a depth of 60 inches throughout the shortgrass habitat from June to September. Deep root systems of the big and little bluestem enabled these species to secure water

from levels near the water table. A close correlation between the amount of soil moisture and rainfall was noted during the season.

Cover of perennial grasses in this area was not as great as in pastures to the west near Hays. Shortgrass habitats were well protected by a matlike cover of nearly pure buffalo grass, an indicator of misuse in past years. Midgrass habitat was subject to severe sheet erosion and the tallgrass habitat was frequently flooded by overflow during spring rains, though little affected by erosion.

Forbs were quite abundant in this area, thriving best on the mesic midgrass habitat. Wild alfalfa was probably the most valuable forb although it was exceeded in numbers by sages, ragweed, and the wavy leaved thistle. Many forb seedlings died during the mid-summer drought.

Seasonal yields of grasses on all three habitats were limited by the drought to 1,000, 760, and 1,020 pounds per acre, respectively, on the shortgrass, midgrass and tallgrass habitats. Shortgrass production was especially limited during June, July, and August. Unusually high weed yields on areas clipped monthly were due to production of Japanese brome. Forb production was also limited due to drought.

Growth rate was a measure of the effect of the drought upon the vegetation in the different habitats. Shortgrass yields were greatest in early spring, declining in midsummer and again renewing growth in September. Grasses in both midgrass and tallgrass habitats, although starting late in the spring, continued to produce during the dry months of midsummer.

Water, protein, and fat content declined similarly in all species of grasses, from highs in early spring to lows in August. The cattle made most rapid gains during May and early June. Japanese brome was of considerable importance in contributing to their diet during May and early June. Big bluestem was the most important perennial grass.

Mineral constituents (calcium and phosphorus) were found to be less than in similar species analyzed from near Hays, Kansas (Runyon, 1932). These elements, however, were present in sufficient amounts that supplements were not necessary for growth and fattening.

Utilization of grasses during May provided approximately 16 pounds dry weight of grass per day per animal unit. Nearly one-third of the grass consumed in May was Japanese brome. In June, consumption dropped to 14.2 pounds per day and in July, it increased to 20 pounds per day. Increased utilization and decreased production during July became apparent as overgrazing occurred, especially near watering places.

Net gains of 2.5 pounds per day per animal unit were made during the 90 - day grazing period. Most rapid gains occurred during

the 45 days of grazing by dry cows. Gains during the last 45 days were made by dry cows and growing calves. The cows which had calves gained little, if any, during the intense heat of July and when flies were abundant.

Japanese brome contributed much more to early gains than most operators realize. Greater gains could be obtained if Japanese brome could have been more heavily utilized during early spring. Also increased early spring grazing would aid in controlling further infestation of this species by limiting seed production.

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Bryophytes Of Kansas

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After some years of collecting bryophytes in Kansas and Missouri and a review of the scanty literature on collections here, it was decided a new list should be made, bringing the literature up to date and, as Smyth and Smyth(10) said, bringing "botanical classification into harmony with itself."

Reports on Kansas collections apparently begin with Cragin's first published reports by Rau in the Washburn College Bulletin 1884-1886 followed by Renauld and Cardot(6) and Miss Reed's extensive listing of 165 species in 1893(5). Smyth and Smyth(7-10) published several lists from 1892 to 1911, mostly duplicating the listings of Renauld and Cardot and of Miss Reed. Many of their reports probably were not based on herbarium specimens as they speak of some of the species as being "frequent", "occasional", "common", etc. Husnot, Lesquereaux and James and

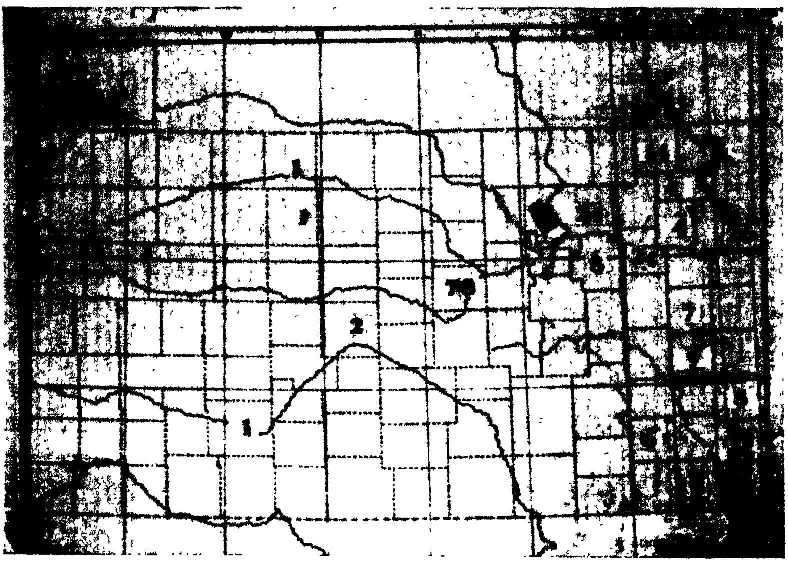

Fig. 1. Map showing distribution, by counties, of mosses reported in the literature.

Kellerman each reported a few mosses from Kansas. Among the other extensive collections were those of Dr. Joseph Henry (reported by Ren. & Card.) and of Miss Grace Meeker, who died last year. Miss Meeker's earlier collections were reported by Reed and by Smyth but efforts to

locate her later collections, if any, have been futile to date. We collected 17 species of mosses in Crawford County State Park[3] a few years ago. Specimens of these collections are now in the herbaria of William Jewell College, KSTC of Pittsburg, and the Sullivant Collection at Duke University. Mr. R. L. McGregor of Kansas University is studying the herbarium specimens now available and hopes (personal correspondence) to publish on these in the near future.

Since 1939, we have found the following new county (and state*) records, specimens of which are in the William Jewell College Herbarium (accession numbers given) and the herbaria of the Sullivant Moss Society at Duke University and University of Cincinnati for mosses and hepatics, respectively.

*Bruchia sullivantii Aust. No. 1072, unplowed field, 2 miles west of Hepler, Crawford County.

Bryum argenteum (L.) Hedw. No. 200, railroad right of way, NE of auditorium, Altoona, Wilson County.

———No. 1068, unplowed field, 2 miles west of Hepler, Crawford County.

Dicranella heteromalla (Hedw.) Schrimp. No. 764, creek bank, 2 miles west of Hepler, Crawford County.

Hygroamblystegium irriguum (Wils.) Loeske No. 772, roadside ditchbank, 2 miles west of Hepler, Crawford County.

Orthotrichum pumilum Dicks. No. 1066, elm tree in old orchard, 2¼ miles west of Hepler, Crawford County.

Pohlia nutans (Hedw.) Lindb. No. 763, creek bank, 2 miles west of Hepler, Crawford County.

*Tortula pagorum (Milde) DeNot, No. 201, 202, bark of elm 1½ blocks NE of auditorium, Altoona, Wilson County.

Ricia beyrichiana Hampe, No. 1073, unplowed field, 2 miles west of Hepler, Crawford County.

Riccia frostii Aust. No. 1074, unplowed field, 2 miles west of Hepler, Crawford County.

The following mosses, previously not reported from Kansas were recently seen in the Herbarium of the Chicago Museum of Natural History:

Bryum bicolor Dicks. collected by Paul D. Voth, Reno County. 1944

Didymodon trifarius (Hedw.) B & S Wm. R. Maxon, Apr. 1912 (locality not given)

Fontinalis missourica Card. E. Hall, "headwaters of Neosho River" (Greenwood Co.?) Aug. 1870

Orthotrichum pusillum Mitt. Paul D. Voth, Reno County, 1944.

The map (Fig. 1) shows the distribution of mosses by counties, the numbers indicating the number of species which have been reported in the literature for a particular county. From this it may be seen that the bryophytes have not been studied and reported for most of the state. It is to be hoped that this study will provide a stimulus for further taxonomic studies of Kansas bryophytes.

For the lists given below, the synonymity was traced on the bryophytes reported in the literature and, without verifying the identification of those reported, are listed below according to author with the synonyms of the report following in parentheses. Following this list is a second list (Table III) of those reported which to date have not been reduced to synonyms as they are not listed in Grout[4], or in Frye and Clark[1, 2].

Table I. Mosses reported in literature, listed by author. Nomenclature is that used by Grout[4].

Bibliographic reference number	7-9	5	10	3
Amblystegiella confervoides (Brid.) Loeske		x	x	
(Amblystegium confervoides, Hypnum confervoides)				
Amblystegiella subtilis (Hedw.) Loeske	x			
(Amblystegium subtile)				
Amblystegium compactum (CM) Aust.			x	
Amblystegium serratum)				
Amblystegium serpens (Hedw.) Bry. Eur.	x	x	x	
(Hypnum serpens)				
Amblystegium varium (Hedw.) Lindb.	x	x	x	x
(Hypnum radicale)				
Anomodon attenuatus (Schreb., Hedw.) Hueben	x	x	x	
Anomodon minor (PB) Lindb.	x	x	x	
(Anomodon obtusifolius)				
Anomodon rostratus (Hedw.) Schimp.	x	x	x	
(Leskea rostrata)				
Archidium hallii Aust.		x	x	
Aschisma kansanum Andrews	x	x		
(Phascum carniolicum)				
Astomum muhlenbergianum (Sw.) Grout		x	x	
(Astomum crispum, A. sullivantii)				
Atrichum angustatum (Brid.) Bry. Eur.	x	x	x	x
(Atrichum xanthopelma)				
Atrichum undulatum (Hedw.) Beauv.	x	x	x	
Atrichum undulatum minus (Lam. & deCan.) Web. & Mohr.				
(reported by Grout)				
Atrichum undulatum selwyni (Aust.) Grout		x	x	
(Atrichum undulatum altecristatus)				
Barbula convoluta Hedw.		x		
Barbula fallax Hedw.	x	x		
(Barbula acuminata)				
Barbula unguiculata Hedw.	x	x	x	x
Bartramia pomiformis (L.) Hedw.	x	x	x	
Brachythecium acutum (Mitt.) Sull.	x	x	x	
(Hypnum acutum, H. riparium serratum)				
Brachythecium oxycladon (Brid.) J. & S.	x	x	x	
(Brachythecium laetum, Hypnum laetum)				
Brachythecium oxycladon dentatum (L & J) Grout		x *		
(Brachythecium laetum dentatum)				

Bibliographic reference number	7-9	5	10	3
Brachythecium plumosum (Sw.) Bry. Eur.		x	x	
(Brachythecium flagellare, Hypnum plumosum)				
Brachythecium rutabulum (L.) Bry. Eur.		x	x	
(Hypnum rutabulum)				
Brachythecium salebrosum (Hoffm.) Bry. Eur.		x		x
(Brachythecium laevisetum, B. salebrosum longisetum)				
(Hypnum salebrosum, H. s. longisetum)				
Brothera leana (Sull.) C.M.	x			
(Campylopus leanus)				
Bryum argenteum (L.) Hedw.	x	x	x	
Bryum bimum Schreb.	x	x	x	
(Bryum pseudotriquetrum)				
Bryum caespiticum L.	x	x	x	
Bryum pendulum (Hornsch.) Sch.	x	x	x	
(Bryum cernuum)				
Campylium chrysophyllum (Brid.) Bryhn.	x	x	x	x
(Hypnum chrysophyllum)				
Campylium hispidulum (Brid.) Mitt.	x	x	x	x
(Hypnum hispidulum)				
Campylium polygamum (Bry. Eur.) Bryhn.		x		
(Hypnum polygamum)				
Campylium stellatum (Schreb. Hedw.) Lang & C. Jens.		x		
(Hypnum stellatum)				
Ceratodon purpureus (Hedw.) Brid.	x	x	x	
Chamberlainia acuminata (Hedw.) Grout			x	x
(Brachythecium acuminatum, B. setosa, B. setosum)				
(Hypnum acuminatum)				
Climaceum americanum Brid.	x		x	
Climaceum dendroides (L.) Web. & Mohr.	x	x		
Desmatodon obtusifolius (Schwaegr.) Jur.		x		
(Desmatodon arenaceus)				
Desmatodon plinthobius S & L		x		
Dicranella heteromalla (Hedw.) Schrimp.	x	x	x	
(Campylopus henrici)				
Dicranella rufescens (Dicks. Sm.) Schimp.	x	x		
Dicranella varia (Hedw.) Schimp.	x	x	x	
Dicranum fuscescens Turn.	x	x	x	
Dicranum scoparium (L.) Hedw.	x	x	x	
Didymodon recurvirostris (Hedw.) Jenn.	x	x	x	
(Didymodon rubellus)				
Didymodon tophaceus (Brid.) Jur.	x	x		
(Trichostomum tophaceus)				
Ditrichum lineare (Sw.) Lindb.		x	x	
(Leptotrichum vaginans)				
Ditrichum pallidum (Schreb. Hedw.) Hampe.		x	x	
(Leptotrichum pallidum)				
Ditrichum pusillum (Hedw.) EGB	x	x		
(Leptotrichum tortile, L. t. pusillus, L. t. vaginans)				
Drepanocladus aduncus (Hedw.) Warnst.	x	x	x	
(Harpidium aduncum)				
(Hypnum aduncum)				
Drepanocladus aduncus kneiffii (Bry. Eur.) Warnst.				x
Entodon cladorrhizans (Hedw.) CM	x	x	x	
(Cylindrothecium cladorrhizans)				
Entodon compressus (Hedw.) CM	x	x	x	
(Cylindrothecium compressum)				
Entodon seductrix (Hedw.) CM	x	x		x
(Cylindrothecium seductrix)				
Entodon sullivantii (C. M.) Lindb.		x		
(Cylindrothecium sullivantii)				

Bibliographic reference number	7-9	5	10	3
Ephemerum crassinervum papillosum (Aust.) R & C	x	x	x	
(Ephemerum papillosum, E. spinulosum)				
Eurhynchium hians (Hedw.) J & S	x	x	x	
(Hypnum hians, Oxyrhynchium hians)				
Eurhynchium praelongum (Dill. L.) Bryhn.		x		
(Hypnum praelongum)				
Eurhynchium rusciforme (Neck) Milde.	x	x	x	
(Hypnum rusciforme, Oxyrhynchium riparioides)				
(Rhynchostegium rusciforme, R. r. inundatum)				
Eurhynchium serrulatum (Hedw.) Kindb.	x	x	x	x
(Hypnum serrulatum, Rhynchostegium serrulatum)				
Eurhynchium strigosum (Hoffm.) Bry. Eur.	x	x	x	
(Eurhynchium pulchellum, Hypnum strigosum)				
Fabronia ciliaris (Brid.) Brid.		x	x	
(Fabronia octoblepharis)				
Fissidens bryoides Hedw.		x	x	
Fissidens bryoides incurvus (Starke) Monkem.		x		
(Fissidens bambergeri, F. incurvus minutulus)				
Fissidens cristatus Wils.	x	x		
(Fissidens decipiens)				
Fissidens exiguus Sull.	x			
(Fissidens incurvus exiguus)				
Fissidens minutulus Sull.	x			
Fissidens obtusifolius Wils.		x	x	
Fissidens obtusifolius kansanus R & C	x	x	x	
(Fissidens kansanus)				
Fissidens osmundioides Hedw.	x	x	x	
Fissidens taxifolius Hedw.	x			x
Fontinalis dalicarlica Bry. Eur.		x	x	
Grimmia alpicola rivularis (Brid.) Broth.	x	x		
(Grimmia apocarpa rivularis)				
Grimmia apocarpa (L.) Hedw.	x	x	x	
Grimmia apocarpa conferta (Funck.) Spreng.	x	x		
(Grimmia conferta compacta)				
Grimmia apocarpa conferta obtusifolia Bry. Eur.		x		
(Grimmia conferta obtusifolia)				
Grimmia calyptrata Hook.	x	x		
Grimmia laevigata (Brid.) Brid.	x	x		
(Grimmia leucophaea)				
Grimmia olneyi Sull.		x		
Grimmia pilifera Beauv.	x	x		
(Grimmia pennsylvanica)				
Grimmia rau Aust.		x	x	
(Coscinodon renauldi)				
Grimmia wrightii Aust.	x	x	x	
(Coscinodon wrightii)				
Gymnostomum aeruginosum Sm.		x	x	
(Gymnostomum rupestre)				
Hedwigia ciliata (Ehrh.) Hedw.	x	x		
Homomallium adnatum (Hedw.) Broth.		x	x	
(Amblystegium adnatum, Hypnum adnatum)				
Hygroamblystegium fluviatile (Sw.) Loeske		x	x	
(Amblystegium fluviatile, Hypnum fluviatile)				
Hygroamblystegium irriguum (Wils.) Loeske		x	x	
(Amblystegium irriguum, Hypnum irriguum)				
Hygroamblystegium noterophilum (Sull.) Warnst.		x		
(Hypnum irriguum spinifolia)				
Hygroamblystegium orthocladum (PB) Grout		x	x	
(Amblystegium orthocladon, Hypnum orthocladon)				

Bibliographic reference number	7-9	5	10	
Hygrohypnum alpestre (Sw., Hedw.) Loeske		x		
(Hypnum rivulare)				
Hypnum curvifolium Hedw.	x	x	x	
Hypnum vagans Drum.	x	x	x	
(Brachythecium rivulare)				
Leptobryum pyriforme (L.) Schimp.	x	x	x	
Leptodictyum riparium (L., Hedw.) Warnst.	x	x	x	x
(Amblystegium riparium, A. r. cariosum)				
(Hypnum riparium, H. r. cariosum)				
Leptodictyum trichopodium kochii (Bry. Eur.) Broth.		x	x	
(Amblystegium kochii, Hypnum kochii)				
Leptodictyum vacillans (Sull.) Broth.	x			
(Amblystegium vacillans, Hypnum vacillans)				
Leskea gracilescens Hedw.				x
Leskea obscura Hedw.	x	x	x	
Leskea polycarpa (Ehrh.) Hedw.	x	x	x	
Leucobryum albidum (Brid.) Lindb.		x		
(Leucobryum minus)				
Leucobryum glaucum (Hedw.) Schimp.	x	x	x	
(Leucobryum vulgare)				
Lindbergia brachyptera austinii (Sull.) Sharp.		x	x	
(Leskea austinii)				
Mnium affine Bland	x	x	x	
Mnium cuspidatum (L.) Leyss.	x	x	x	x
Myrinia pulvinata (Wahl.) Sch.		x		
(Leskea pulvinata)				
Orthotrichum anomalum Hedw.	x	x		
Orthotrichum cupulatum (Hoffm.) Brid.	x	x	x	
Orthotrichum pumilum Dicks.	x	x		
(Orthotrichum brachytrichum)				
Orthotrichum speciosum Nees.	x	x		
Orthotrichum strangulatum Schwaegr.	x	x	x	
Phascum cuspidatum (Schreb.) Hedw.	x	x	x	
Phascum cuspidatum americanum R & C (?)	x	x	x	
(Phascum cuspidatum piliferum)				
(Mniobryum floerkeanum, M. f. henrici)				
Philonotis glaucescens (Hornsch) Paris (reported by Grout)				
Philonotis gracillima Angstr. (reported by Grout)				
Philonotis longiseta (Rich.) EGB		x		
(Bartramia radicalis)				
Philonotis marchica (Willd.) Brid. (reported by R & C.)				
Philonotis muhlenbergii (Schwaegr.) Brid.	x	x		
Physcomitrium acuminatum (Schleich) Bry. Eur.	x	x	x	
Physcomitrium hookeri Hampe.	x	x	x	
Physcomitrium kellermanni EGB	x	x	x	
Physcomitrium turbinatum (Mx.) Brid.	x	x	x	x
(Physcomitrium pyriforme)				
Plagiothecium denticulatum (L., Hedw.) Bry. Eur.			x	
Plagiothecium geophilum (Aust.) Grout	x	x	x	
(Eurhynchium, Hypnum, Rhyhchostegium geophile)				
Plagiothecium sylvaticum (Huds. Brid.) Bry. Eur.	x	x	x	
(Hypnum sylvaticum)				
Pleuridium bolanderi C. M.		x	x	
Pohlia annotina (Hedw.) Loeske	x	x	x	
(Webera annotina)				
Pohlia nutans (Schreb.) Lindb.		x	x	
(Webera nutans)				
Pohlia wahlenbergia (Web. & Mohr.) Grout	x	x	x	
(Webera albicans)				

Bibliographic reference number	7-9	5	10	3
Polytrichum commune Hedw.	x	x		
Polytrichum juniperinum Hedw.	x	x	x	
Polytrichum piliferum Hedw.	x	x		
Pterigoneurum subsessile (Brid.) Jur.	x	x	x	
(Pharomitrium subsessile, Pottia subsessilis)				
Pterigoneurum subsessile henrici (Rau) Wareham	x	x		
Barbula henrici)				
Ptychomitrium incurvum (Muhlen) Sull.	x	x	x	
(Ptychomitrium pygmaeum)				
Pyramidula tetragonia (Brid.) Brid.	x	x	x	
(Physcomitrium tetragonium)				
Pylaisia intricata Bry. Eur.	x	x	x	
(Pylaisia velutina)				
Pylaisia selwyni Kindb.		x		
Rhacomitrium aciculare Brid.		x		
Rhodobryum roseum (Weis.) Limpr.		x	x	
(Bryum ontariense)				
Sphagnum tabulare Sull.		x		
(Sphagnum molle)				
Seligera pusilla (Hedw.) Bry. Eur.	x	x		
Thelia asprella Sull.	x	x	x	
Thuidium abietinum (L., Brid.) Bry. Eur.		x	x	
(Hypnum abietinum)				
Thuidium delicatulum (Hedw.) Mitt. (Ren. & Card. reported possibly collected)				
Thuidium microphyllum (Sw., Hedw.) Best	x	x	x	x
(Thuidium gracile, Hypnum gracile)				
Thuidium recognitum (Hedw.) Lindb.		x	x	
(Hypnum recognitum)				
Timmia megapolitana Hedw.	x	x	x	
(Timmia cucullata)				
Tortella caespitosa (Schwaegr.) Limpr.	x	x	x	
(Barbula caespitosa)				
Tortula mucronifolia (Schwaegr.)	x	x		
(Barbula mucronifolia)				
Tricholepis nigrescens (Sw.) Grout	x		x	
(Meteorum nigrescens)				
Weisia viridula Hedw.	x	x	x	x
(Weisia viridula stenocarpa)				

Table II. Liverworts reported by Smyth & Smyth[18]. Nomenclature is that used by Frye and Clarke[1, 2].

Anthoceros laevis L.
Anthoceros punctatus L.
Asterella tenella (L.) Beauv.
(Fimbriaria tenella)
Chiloscyphus pallescens (Ehrh.) Dum.
(Chiloscyphus adscendens)
Chiloscyphus polyanthus (L.) Corda
Conocephalum conicum (L.) Wiggers
Fossombronia angulosa Reddi
Frullania squarrosa (R. Bl. & N.) Dum.
Leucolejeunea clypeata (Schwein) Evans
Lophocolea heterophylla (Schrad.) Dum.
Lophocolea minor Nees.
Marchantia polymorpha L.
Notothylas orbicularis (Schw.) Sull.
Pallavicinia lyellii (Hook). S. F. Gray
Pellia endiviaefolia (Dicks.) Dum.
(Pellia calycina)
Preissia quadrata (Scop.) Nees.
(Preissia commutata)
Ptilidium ciliara (L.) Nees.
Reboulia hemispherica (L.) G. L. & N.
(Asterella hemispherica)
Riccardia latifrons Lindb.
(Aneura latifrons)
Riccia crystallina L.
Riccia fluitans L.
Riccia frostii Aust.

Table III. Synonymity not determined.

Bibliographic reference of author reporting:	7-9	5	10	3
MOSS				
Amblystegium cariosum Sull.			x	
Amblystegium porphyrrizon Lind. ("seems to be identical with A. hygrophilum Sch." Ren. & Card.)			x	
Amblystegium radicale Bry. Eur.	x			
Dicranum undulatum Turn.	x			
Hypnum porphyrrizum Lindb.	x		x	
Mnium affine elatum Bry. Eur.		x		
Mnium elatum Bry. Eur.		x	x	
Orthotrichum cupulatum minus Sull.	x	x		
Trichostomum crispum Bruch (Grout says not north of Mexico.			x	
LIVERWORTS				
Frullania virginica Lemm			x	
Jungermannia schraderi Mast.			x	
Riccia lescuriana Aust. (R. beyrichiana Hampe ?)			x	

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Wechsler's Mental Deterioration Index In the Diagnosis of Organic Brain Disease

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Introduction

During the last war, the clinical psychologist in an army neuropsychiatric hospital participated in the differential diagnosis of organic brain pathology. He applied psychological test methods to the detection, measurement and delineation of impaired mental functioning resulting from brain damage. One group of patients he saw were those whose hospitalization originated in demonstrable brain injuries. The focus here was determination of the nature and degree of psychological deficit present. Periodic retesting measured improvement consequent on such therapeutic procedures at debridement, removal of necrotic brain tissue, cranioplasty, and general recovery of function with time.

A second group included those whose hospitalization followed head trauma, but for whom the presence or absence of cerebral pathology at the time of examination or point of discharge was not so clearly discernible. These soldiers presented a history of exposure to concussive blast, wounds and blows to the head, skull fractures and concussions, in many cases accompanied by loss of consciousness, hemiplegias, aphasia, and other transient or residual neurological disturbances. Following the clearing of these disturbances, many men still retained a variety of subjective symptoms, although they were now neurologically negative. The diagnostic question was: If these subjective complaints were referable to subdural residuals, would this be perceptible on psychological testing?

A third group comprised those soldiers whose onset of illness was ostensibly not associated with any organically noxious events. They had vague cephalgic complaints, dizziness, syncope, epileptiform seizures, and other symptoms requiring diagnostic exclusion of brain pathology. All three groups posed crucial disposition questions relating to restoration to military duty, medical discharge, disability compensation and pension claims. In the latter two groups, psychological test results were studied in an effort to distinguish presumptive organic cases from clear-cut psychoneurotic or hypochondriacal syndromes. Often, post-traumatic neurotic over-lay obscured this effort and tenable distinction was not possible.

Read at the meeting of the Kansas Academy of Science, Kansas Psychological Association, in Pittsburg, Kansas, April 30, 1948.

Problem

The psychological test report on a patient with organic impairment usually described the extent of functional loss present by means of such qualifying adjectives as "mild," "moderate" or "severe." A percentage-loss method of expressing this would of course be more specific in describing degree of incapacitation. The neurologist may express sensory-motor deficit in terms of per cent of function lost. Thus an upper limb paralysis might be reported as causing 40 per cent loss of function in that arm. A ready formula for similar quantification of impaired psychological functioning was available in Wechsler's "differential-test-score method of measuring mental deterioration."[7] This is offered by Wechsler as a diagnostic index of the presence of impairment and presumably also as a quantitative expression of its extent.

Wechsler defines deterioration "primarily as an impairment or loss of function" which may manifest itself in "mere regression to primitive types of response," or in "disorganization."[7] Implicit in his concept of mental deterioration is the assumption that psychological impairment attendant upon organic brain disease or traumatic brain injury is essentially the same process as waning of mental abilities with natural increase in age or senescent decline. The same psychological functions are held to be affected.

His index of deterioration is thus based upon the long observed fact that certain mental abilities show less efficiency loss with age than others. The ratio of those functions which "Hold" up with advancing age to those which "Don't Hold" is expressed in the formula $\frac{\text{HOLD-DON'T HOLD}}{\text{HOLD}}$. The "Hold" functions are measured by the weighted scores of the Information, Comprehension, Object Assembly, and Picture Completion subjects of the Wechsler-Bellevue scale. The "Don't Hold" functions are identified in the Digit Span, Arithmetic, Digit Symbol, and Block Design subtests. After allowing for "normal decline with age", the remaining percentage loss is interpreted as follows: loss greater than 10 per cent is indicative of possible deterioration"; loss in excess of 20 per cent is "definite" evidence of it. These points "correspond roughly to deviations of -1 P. E. and -2 P. E. from the mean at age 20-25."

A few cases in which this index played a role in the differential diagnosis of brain pathology prior to the finding of "clear-cut clinical or neurological evidence" are cited by Levi, Oppenheim and Welchsler.[5] In addition, they report successful use of the index for "distinguishing organic memory impairment from hysterical amnesia"; "distinguishing between mental deficiency and intellectual deterioration (not necessarily at a defective level)"; "differentiating between psychosis with and without organic deterioration." However, nowhere do Wechsler or his co-workers

present evidence of validation for this index. Nor has there been any systematic application of this method to a large number of known organic subjects. Beyond the presentation of a few cases in which the index was helpful, we have no information on how dependable a measure it is. That is, how consistently is it positively indicative? How often does it fail to be indicative when it should be, and how frequently does it yield false positives?

Boehm and Sarason[1] applied the index in an attempt to distinguish intellectual deterioration from mental deficiency. Their results "call into question" Wechsler's claim for this index. They point out the fallacy in reasoning that if mental deterioration causes comparatively low scores on certain tests, then the presence of such low scores can be consistently taken as evidence of deterioration. Johnson[4] used the index in a study of "feebleminded without seizures," "feebleminded with seizures" and "epileptics who were not feebleminded." She found a "high correlation between the deterioration quotient and chronological age in the epileptic group and a low correlation in the feebleminded group." Sloan[6] using the index with a group of "high grade mental defectives" found "marked deterioration as measured by Wechsler's deterioration quotient," in the absence of actual clinical evidence of such deterioration. He therefore concluded that the index is "not valid" for such use. Applying it to a group of brain-injured patients similar to our group (A), Allen[8] obtained results diagnostically more favorable to the index than ours. "This formula definitely screened out 54 per cent of the total study group of 50 patients. It did not disclose any appreciable loss in 28 per cent of the cases while it pointed up a trend loss in the remaining 18 per cent."

Procedure

The writer applied the index of deterioration to neuropsychiatric patients in an army hospital falling into three distinguishable groups: (A) clinically ascertained cases of brain damage; (B) patients with verified head trauma, but equivocal diagnostic evidence of subdural lesion; (C) non-traumatic cases with symptoms requiring diagnostic exclusion of cerebral involvement. In all three groups our experience with the index was inconsistent. It could not be relied upon, neither as a diagnostic indicator, nor as a quantitative measure of deterioration.

In order to test this conclusion systematically, a study was made on 30 cases within the first two groups: that is, (A) patients with medically diagnosed brain damage, and (B) patients who suffered head trauma, and for whom such diagnosis was presumptive but not clearly established. Test records were randomly taken from the files. Only those cases were used

in which both a complete Wechsler-Bellevue test and a diagnostic abstract from the medical chart were immediately available in the file. We thus found 18 cases in group (A) which included 14 cases of penetrating head wounds; one case of thrombosis, middle cerebral artery, right; one case of brain abscess; one case of neurosyphilis, general paresis; one case of a Spanish War Veteran with cerebral arteriosclerosis. There were 12 cases in group (B), all with histories of skull fractures, concussions and contusions. The age range for group (A) was 19 through 44 (the senile case was 76). In group (B) the ages ranged from 20 through 35. The I. Q.'s in group (A) ranged from 61 to 114; in group (B) from 54 to 121.

Results

The HOLD-DON'T HOLD quotients obtained for these cases as a whole were indicative of "definite" deterioration (20 per cent or above) in only 10 patients or one-third of both groups. There was only one additional quotient of "possible" deterioration (11 per cent,), occurring in group (B). These results are without correction for age which would reduce somewhat further the quotients obtained. The specific data are set forth in Tables I and II.

Table I. Deterioration index: Distribution.

DIAGNOSIS	NO. CASES	INDEX					
Group (A)		0	1-9	10-19	20-29	30-39	40-49
Penetrating Head Wounds	14	3	7	0	2	1	1
Thrombosis, Middle Cerebral Artery, Right	1	1	..	..	..	..	..
Brain Abscess	1	.	..	..	..	1	..
Neurosyphilis, General Paresis	1	1	..	..	..	..	..
Senile Cerebral Arteriosclerosis	1	..	..	..	..	..	1
Total	18	5	7	0	2	2	2
Group (B)							
Skull Fractures, Concussions and Contusions	12	6	1	1	2	2	..
Total	30	11	8	1	4	4	2

Table II. Deterioration index: "Possible"—"Definite".

	NO.	10%—19%	20% or >
Group (A)			
Penetrating Head Wounds	14	..	4
Thrombosis, Middle Cerebral Artery, Right	1	..	0
Brain Abscess	1	..	1
Neurosyphilis, General Paresis	1	..	0
Senile, Cerebral Arteriosclerosis	1	..	1
Total	18	..	6
Group (B)			
Skull Fractures, Concussions and Contusions	12	1	4
Total	30	1	10

According to the deterioration quotient, (20 per cent or above), 4 out of the 12 cases in group (B) or one-third would be said to have "definite" indication of organic impairment. In group (A), four out of 14 or less than one-third of the penetrating head wounds, and two of the four remaining cases in this group had a "definite" index of deterioration. In

other words, six out of 18 or only one-third yielded a positive index. Thus Wechsler's index failed to detect two-thirds of the cases in a group of patients with known brain damage. Comparing both groups we find that results in group (A) were no better than those in group (B). We conclude therefore that the index lacks discriminating capacity to distinguish actual brain pathology from those cases of dubious organic diagnosis.

It is noted that the highest deterioration quotient was obtained for our senile patient. The index may conform to Wechsler's claim for age deterioration, but in our experience it failed to discriminate brain damage due to causes other than senescent decline, namely penetrating head wounds. In this group, impairment of psychological functioning varied considerably both clinically and as measured by the Bellevue scale as a whole. Halstead[2], Hebb[3] and others have reported cases in which psychological impairment was minimal or indiscernible to present test methods. It appears that the kind of "deterioration" picked up by Wechsler's formula does not occur with sufficient frequency to justify its use as a detecting device.

Conclusions

1. Wechsler's index of deterioration failed both in detecting and confirming the presence of organic conditions resulting largely from traumatic brain injury.

2. As a percentage-loss method for expressing psychological deficit, it was found inapplicable in two-thirds of such cases.

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The Plains Border Physiographic Section

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Introduction

In the physiographic subdivision of the United States prepared by Fenneman (1931) approximately one third of the area of Kansas is placed in the Plains Border section of the Great Plains physiogrophic province. Furthermore, about two thirds of this section is in Kansas. The section is brought to a narrow point of extinction as it passes southward across the Oklahoma panhandle into north Texas, and is abruptly terminated in southern Nebraska along the north side of the Republican River Valley. North of the Plains Border the High Plains section extends eastward into eastern Nebraska. The eastern boundary of the Plains Border section in Kansas coincides with the province boundary between the Great Plains and the Central Lowlands.

The earliest physiographic districting of Kansas was made by Adams in 1901 and published in the Transactions of the Kansas Academy of Science in 1903 (pp. 109-123). A comparison between the physiographic subdivisions proposed by Adams and Fenneman is presented in Figure 1. The striking contrast between the two sets of boundaries led us to a consideration of the validity of the Plains Border section as defined by Fenneman.

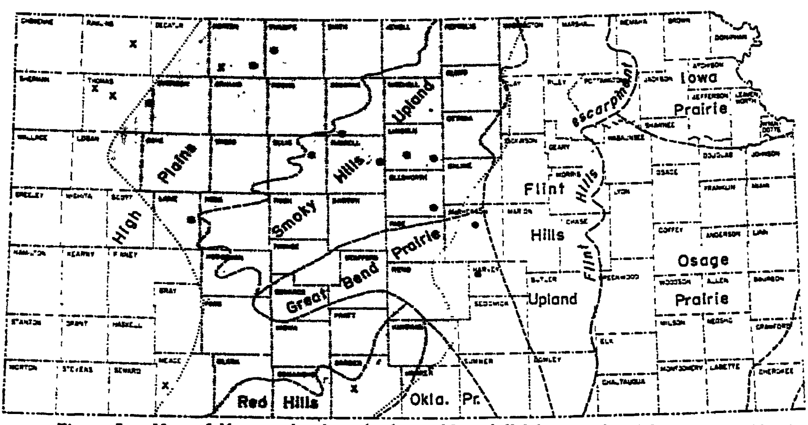


Figure 1. Map of Kansas showing physiographic subdivisions outlined by Adams (1903). The Plains Border section of the Great Plains physiographic province as outlined by Fenneman (1931) is shown by stippled pattern. Locations of photographs included with this paper are shown by dots, and locations of photographs included in "The High Plains Surface in Kansas" (Frye, 1946) are shown by an X.

In 1946 Frye described the surface features of the High Plains section, particularly in Kansas, and discussed the placement of the High Plains-Plains Border boundary. The present paper describes the Plains Border section, recommends the acceptance of Adams' boundary for the eastern limit of the High Plains, and discusses some of the problems involved in a more proper delineation of the Great Plains-Central Lowlands provincial boundary.

Topography and Geology

In northern Kansas, the Plains Border section extends from eastern Decatur County to central Washington County. In the western third of this region the surficial Pleistocene deposits are underlain in the interstream areas by sediments classed as the Pliocene Ogallala formation. In the central third the weak chalky shales of the Smoky Hill member of the Niobrara formation, generally thinly veneered with Pleistocene sediments, occur near the surface and at the eastern edge of this belt the Fort Hays limestone member of the Niobrara forms a prominent and almost continuous east-facing escarpment. The eastern third is underlain by the alternately nonresistant and resistant Carlile shale, Greenhorn limestone, Graneros shale, and Dakota formation, all of Cretaceous age. The western two-thirds of Fenneman's Plains Border section, in the northern tier of Kansas counties, was included by Adams in the High Plains (Pls. 1C, 2B, C). The Ogallala, although it locally occurs as outliers (Pl. 1D) and at some places produces a minor break in topography, does not display a prominent east-facing scarp and the topography of the belt of Ogallala outcrop is hardly distinguishable from that of the upper Niobrara outcrop. This is in part caused by the general mantle of late Pleistocene eolian silt that overlies both Ogallala and Niobrara in the upland areas and by the similarity of the two formations in their resistance to weathering and the absence from both of strong contrast in weathering resistance from bed to bed.

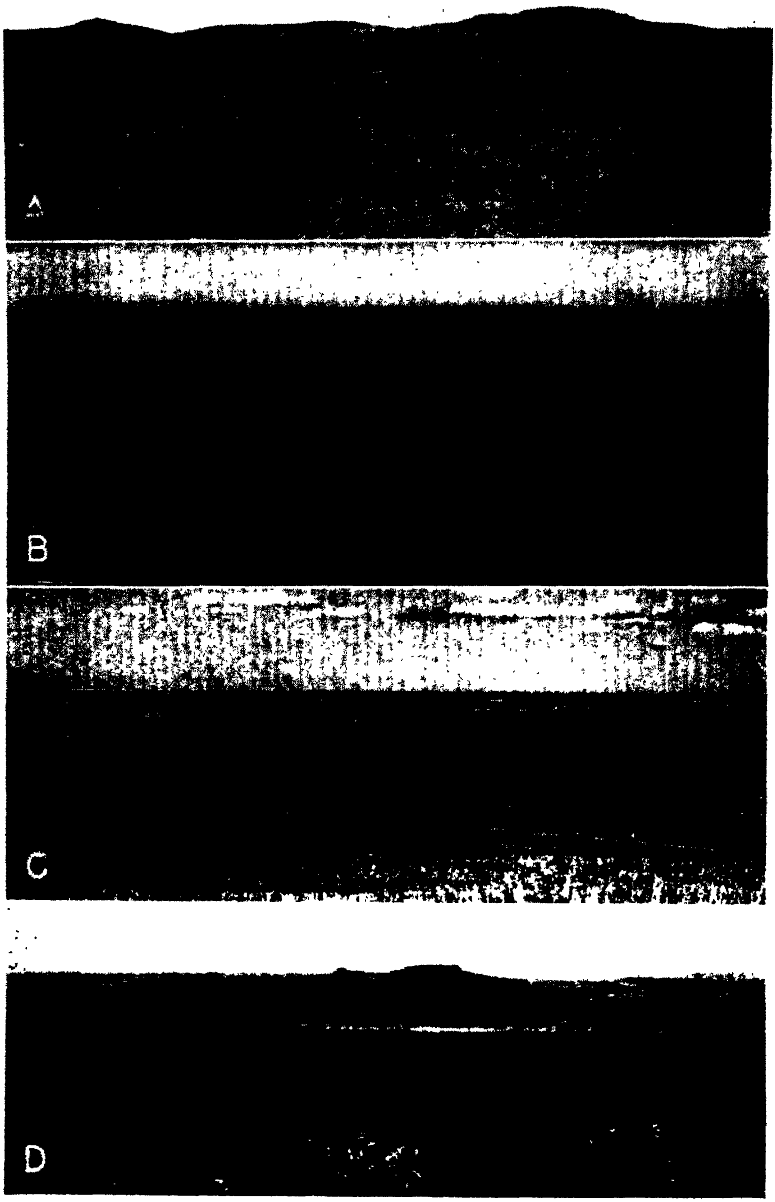
PLATE 1. PLAINS BORDER TOPOGRAPHY

A. Topography developed on Cretaceus sandstones and clays of the Dakota formation in east-central Russell County. This area, approximately in the center of Adams' Smoky Hills, uplands, typifies the northeastern part of the Plains Border section. (Photo by Norman Plummer)

B. Dakota formation topography in southeastern Ellsworth County, near the eastern margin of the Plains Border section. Note meander pattern in foreground. (Photo by Norman Plummer)

C. Loess mantled Cretaceous and Ogallala topography in west-central Phillips County. Although 50 miles east of the limit of Fenneman's High Plains this locality lies well within the High Plains as defined by Adams.

D. Ogallala outlier and loess mantled Cretaceous slopes along Solomon Valley, southeastern Norton County.


A
B
C
D

The eastern third of the section is characterized by a more varied topography which reflects the alternating resistance to weathering of the several Cretaceous bedrock units (Pls. 1A, B; 3B, C), and the lack of uniformity in the upland blanket of late Pleistocene eolian silt so marked in the region farther west.

Southward across the second tier of Kansas counties the Fort Hays escarpment trends generally southwest, and in northern Ellis County this escarpment (Pls. 2A, 3A) approximately bisects Fenneman's Plains Border section. West of the Fort Hays outcrop the topography is comparable to that farther north, and eastward from it the topography is typified by escarpments along the outcrop of the Greenhorn limestone (P1, 3B) and resistant lentils of sandstone in the Dakota formation. Intervening lowlands are developed on relatively weak shales. The upland mantle of eolian silt generally thins southward where the topography is a more accurate reflection of bedrock.

In Ellis, Trego, Gove, and Logan Counties the Smoky Hill Valley forms an elongate lowland belt characterized by long graded valley side slopes (Frye and Smith, 1942). Even the Smoky Hill Valley, however, is relatively constricted where it crosses the Fort Hays outcrops, and the wide graded slopes are best developed in the weaker chalky shales of the Smoky Hill member of the Niobrara formation.

South of the Smoky Hill Valley the Fort Hays scarp continues southwestward across Ness and southern Lane Counties and passes under the Tertiary sediments in northern Finney County. In this area the Ogallala extends eastward nearly to the crest of the scarp. As Fenneman's High Plains-Plains Border boundary line trends southeast from Logan County it crosses the Fort Hays scarp about at its southern extremity in northern Finney County.

PLATE 2. PLAINS BORDER AND CENTRAL LOWLANDS TOPOGRAPHY

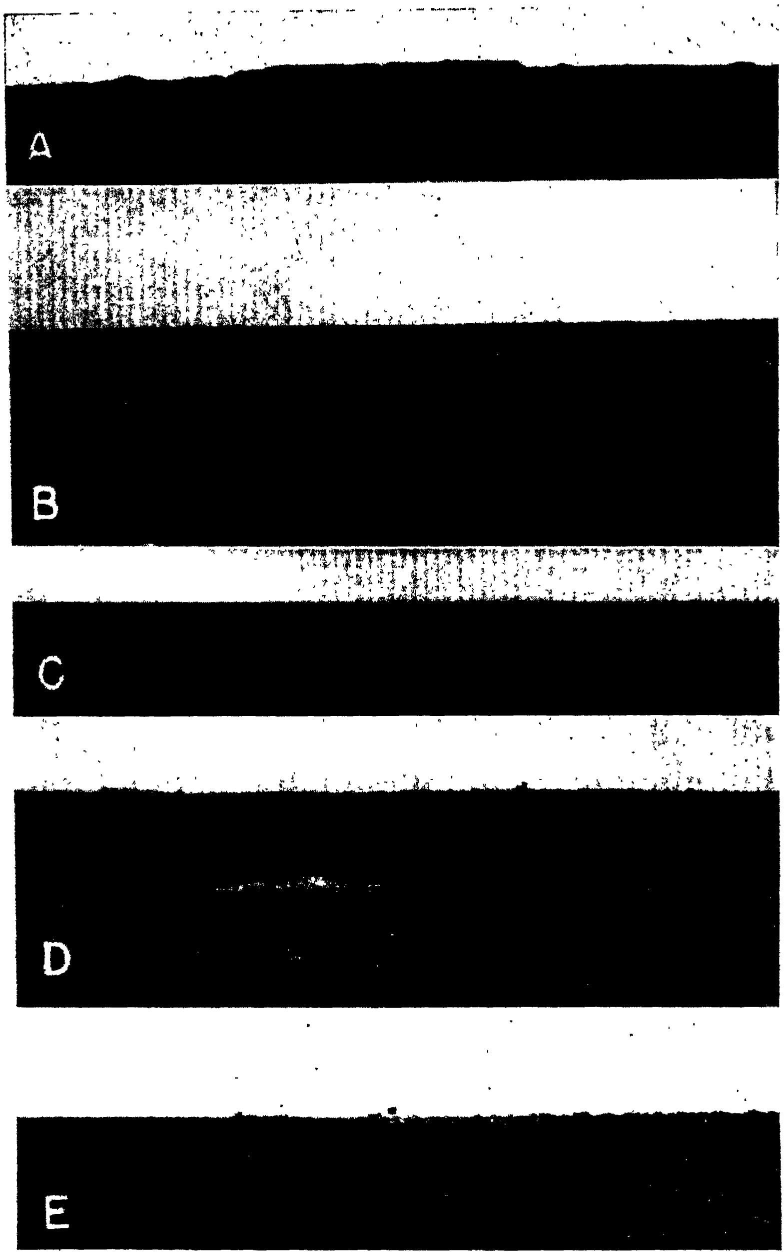
A. Escarpment capped by Fort Hays limestone locally overlain with remnants of Ogallala. Carlile shale underlies the slopes below. Eastern Ellis County. This escarpment marks the eastern edge of the High Plains as defined by Adams, but occurs about midway in the Plains Border section as described by Fenneman.

B. Upland surface underlain by Ogallala formation thinly veneered with eolian sand, east-central Lane County. Within the western part of the Plains Border section although indistinguishable from typical High Plains topography.

C. Upland surface underlain by Ogallala formation blanketed by 40 feet of eolian silt, east-central Thomas County. At the western limit of the Plains Border section.

D. Upland surface underlain by Pleistocene silts in central McPherson County near the western border of the Central Lowlands province, and at the eastern limit of Adams' Great Bend Prairie.

E. Arkansas River alluvial plain in western Harvey County. Central Lowlands, Osage Plains of Fenneman—Great Bend Prairie of Adams.


A
B
C
D
E

Southward from the Smoky Hill Valley the escarpments held up by the Greenhorn limestone and sandstone lentils of the Dakota formation (Cretaceous) become less distinct and pass beneath Tertiary and Quaternary sediments north of Arkansas River.

The topography of the Arkansas Valley region, and particularly the area south of the great bend, presents an aspect totally unlike any area of the Plains Border section in the northern half of Kansas. In Rice, Reno, Barton, Stafford, Pratt, Pawnee, Edwards, and Kiowa Counties there is a region of generally subdued, rolling sand dunes resting on Pleistocene alluvial deposits. Parts of Pratt, Kiowa, Ford, and Meade Counties present flat upland-divide topography, developed on Pliocene and Pleistocene sediments, that is indistinguishable from the topography of the High Plains farther to the west.

South of the Arkansas Valley and the great bend region, particularly in Clark, Comanche, and Barber Counties, still another distinct topographic type is to be found. Escarpments in this area, capped by the Ogallala formation, permian gypsum beds, and in a few places Cretaceous sandstones of the Kiowa and Dakota formations, stand above lowland plains, in many places floored with discontinuous Pleistocene sediments resting on Permian rocks.

Fenneman vs. Adams

The eastern boundary of Fenneman's Plains Border section coincides with his interprovince boundary separating Great Plains from Central Lowlands. Concerning this boundary he states (1931, p. 3): "Throughout the greater part of its length this line is marked by a low east-facing escarpment, definite at some places, elsewhere ragged and deeply indented or transformed by erosion into a belt of hills. At still other places it is absent. Everywhere east of this line the surface is lower . . . in northern Kansas the eastern margin of the Plains province is a hilly belt to be described under the head of the Plains Border. As far south as central Kansas there is a mild contrast between the smoother or more gently rolling Central Lowlands and the higher and more sharply dissected Plains Border." And further (P. 4): "In southern Kansas . . . there is a pronounced escarpment 300 to 400 feet high, ruggedly dissected and locally known as the Red Hills."

It should be noted that this eastern limit for the Great Plains lies just within the eastern margin of Cretaceous outcrop in northern Kansas, and in southern Kansas through a belt of weak Permian shales and siltstones, locally mantled with Pleistocene and Recent deposits. Also, at many places in central Kansas the topography east

of the line on Fenneman's map is equally as rugged as that west of it. The prominent scarp of the Red Hills lies well within the Plains Border section.

Adams (1903) draws the eastern limit of the Great Plains at the crest of the Flint Hills upland, which is held up by resistant lower Permian cherty limestones and constitutes the most prominent topographic feature in eastern Kansas. He did, however, include the Great Bend Prairie and Oklahoma Prairie (note Fig. 1) within his Prairie Plains region (Pl. 2, D and E).

The discrepancy between topography and geology on the one hand and Fenneman's physiographic boundary lines on the other is even greater at the western limit of the Plains Border than it is at the eastern limit. He states (Fenneman, 1931, p. 25): "The actual edge of the High Plains is a very crenulated line marked at many places by a scarp running in and out among stream heads and known as the 'break of the plains.' Several factors combine to develop this escarpment. One is the tight sod cover of the upland which successfully resists erosion. Another is the ground water which readily descends through the porous Tertiary but issues in springs where porous sediments rest on a bed of clay, or on the impervious shale." He states further (p. 26): "The Plains Border becomes clear in northern Kansas where the outcrops of strata of diverse strength and dipping slightly westward afford conditions for east-facing escarpments." A glance at Figure 1 in comparison to a geologic map of Kansas will clearly show that the boundary line Fenneman drew on his map does not coincide at any point in the northern half of Kansas with the eastern margin of the "Tertiary mantle," (more properly termed Ogallala formation) and at some places lies as much as 75 miles west of it. Furthermore, there is no topographic break of any kind in the vicinity of his boundary across this part of the State. Spring sapping could have only a negligible effect on the retreat of the eastern limit of the Ogallala formation in northern Kansas, as no springs are known to occur in such a position although they do occur along deep valleys farther west, and at some places the water table stands below the base of the Ogallala. Plate 2B and C shows flat uplands in the western part of the Plains Border section that are indistinguishable from typical topography of the High Plains farther west. Furthermore, although outliers of Ogallala form scarps at a few localities (Pl. 1D), the topography along the eastern margin of the Ogallala (Pl. 1C) is generally transitional

due in part to the persistent upland mantle of late Pleistocene eolian silt.

Across this part of Kansas Adams (1903) drew the eastern limit of the High Plains much farther east (Fig. 1) at the prominent escarpment produced by the outcrop of the Fort Hays limestone member of the Niobrara formation (Pls. 2A and 3A). This escarpment is the most prominent topographic feature in north-central Kansas.

North of Arkansas River, in northeastern Finney County, the eastern boundaries of the High Plains as drawn by Adams and Fenneman closely approach each other. It is here that the Fort Hays outcrop is crossed by Fenneman's boundary just north of the area where the Fort Hays limestone passes beneath Ogallala cover.

South of Arkansas River, Fenneman's boundary trends slightly west of south and is located about 25 miles west of a prominent scarp produced by the Ogallala formation overlying Permian shales and siltstones. Adams' eastern limit of the High Plains coincides with this scarp in Clark County. He extended that subdivision far to the east in a long loop to include a part of the Arkansas alluvial plain, the broad flat uplands of Kiowa and Pratt Counties, and the southern part of the Great Bend sand dune tract. The boundary as drawn by Adams is supported by a prominent topographic feature across Clark, Comanche, and Barber Counties, but not across Stafford, Edwards, and Ford Counties, whereas Fenneman's boundary is supported by a prominent topographic break at no place south of northeastern Finney County.

Adams and Fenneman are in much closer agreement concerning the minor units included within the Plains Border than they are concerning the section boundaries. The area designated by Adams (Fig. 1) as the Smoky Hills Upland is recognized by Fenneman essentially unaltered. Fenneman's Great Bend Lowland (P. 27)

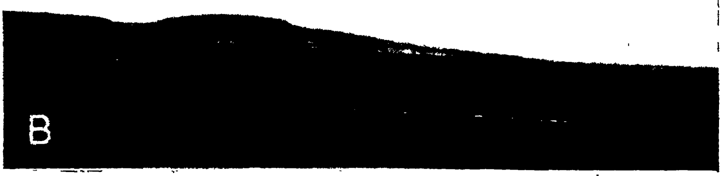
PLATE 3. PLAINS BORDER TOPOGRAPHY ☛

A. Escarpment capped by Fort Hays limestone member of the Niobrara formation; plain in foreground is underlain by Carlile shale. North of Waldo, Osborne County. Adams' east boundary of the High Plains.

B. Pediment-like valley side slope, common along many streams in the central Plains Border section. North side of Saline Valley, sec. 31, T. 12 S., R. 10 W., Lincoln County. Scarp is capped by Jetmore member of the Greenhorn limestone and slope bevels the Lincoln member of the Greenhorn, the Graneros shale, and the Janssen and upper Terra Cotta members of the Dakota formation.

C. Gully interrupted by discontinuous pools in native grass pasture, sec. 11, T. 13 S., R. 7 W., Lincoln County. The sod cover forms a "cap rock" at the upstream end of the pools and the gully floor has a gentle gradient between pools. Such gullies within the Plains Border section characterize native grass pastures where adjacent fields have not been plowed.

includes the western part of Adams' Great Bend Prairie and eastern loop of High Plains (Fig. 1). The Red Hills area of both is essentially the same well-defined topographic unit.



Conclusions

A consideration of topography and geology in the Kansas region seems to leave few if any valid reasons for the existence of a Plains Border section as delineated by Fenneman. His western boundary of the Plains Border (and eastern boundary of the High Plains) is supported neither by topography nor geology and seems to coincide with nothing but a line of approximately equal rainfall — at best a vague means of limiting a physiographic section. Adams' east limit of the High Plains, on the other hand, coincides with both a prominent topographic break and geologic boundaries throughout most of its distance. In the northern part of the State, Adams' High Plains show little or no reflection of bedrock and are largely mantled by late Pleistocene sediments whereas the region to the east is dominated by cuestas, tabular uplands, and ridges held up by Cretaceous and older bedrock units. Near the southern border of Kansas Adams' High Plains limit coincides equally well with a scarp capped by relatively resistant Tertiary sediments, and only across the Arkansas River Valley and in the Great Bend dune tract is it unsupported by features observable in the field. Furthermore, this line can be extended northward into Nebraska and southward into Oklahoma and Texas and merged with previously defined limits of the High Plains without seriously disturbing the districting in those regions. It is our judgment that Adams' boundary line should be recognized as the eastern limit of the High Plains section.

Fenneman's eastern limit to the Plains Border has somewhat more justification than the western limit. However, it might be argued that a major provincial boundary should be drawn at a clearly recognizable topographic feature, either the Fort Hays limestone escarpment or the crest of the Flint Hills. If the provincial boundary is drawn at the east margin of the High Plains along the Fort Hays limestone and the Red Hills escarpments, the Plains Border section can be conveniently eliminated and the belt of Cretaceous cuestas included with the similar Permian and Pennsylvanian cuestas farther east in the Central Lowlands province. Should such a westward extension of the Central Lowlands prove untenable then the Flint Hills crest should be considered as a possible location for the provincial boundary line. The Flint Hills have been a prominent feature throughout the late Cenozoic physiographic history of Kansas. In Kansas only the Kansas River now flows across this series of cuestas and the surficial sediments on the flanks of the upland

clearly show that the Flint Hills stood as a major drainage divide during late Tertiary and early Pleistocene time.

Even though the topography of Kansas is relatively subdued and local relief is not great, there are recognizable topographic features that are the product of the stratigraphy, structure, and physiographic history of the region. Seemingly, it is better practice to utilize such features as boundaries for physiographic subdivision than to draw the largely unsupported sweeping generalities indicated by the boundaries as drawn by Fenneman.

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A Progress Report On Some Experiments With Cola Beverages

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The present paper presents the results of two of a series of experiments on the taste discrimination and identification of common cola beverages. The general hypothesis guiding our study concerned itself with the following questions: Can subjects discriminate from among a series of common cola beverages? What will be the pattern of their naming responses to identical samples of a cola drink as compared with samples of different colas? What will be the effect of the introduction of a relatively unfamiliar cola beverage upon S's pattern of identification responses?

Experiment I involved two groups of subjects. Group I, consisting of 108 Ss, was given one one-ounce sample of each of the following four Cola beverages: Coca-Cola, Pepsi Cola, RC Cola, and Vess Cola. Another group of 60 Ss was given the *same* Cola drink in all four trials.

Subjects were admitted individually into the experimental room and were invited to sit down. The following instructions were then read:

> We would like to have you taste and identify some cola drinks. You will be told in what order and when you are to drink them. After you have finished each sample, report your identification to E and take enough water from the paper cup before you to rinse your mouth well.

A tray containing four one-ounce glasses of Coca-Cola, Pepsi Cola, RC Cola, and Vess Cola respectively was placed before the S. He was then told to drink the beverages labelled w, x, y, and z in the order indicated to him. Samplings were spaced about a minute apart, S's name and other information being recorded in the interval between drinks.

The order of presentation of the beverages, determined pre-experimentally, was such that each of the stimuli appeared in the first, second, third, and fourth position the same number of times. This counter-balanced order was used to preclude the operation of position effects or stimuli interactions orally. All beverages were kept out of S's sight and were placed in a refrigerant maintained at approximately 5° C.

Part II.

In part II, 60 Ss were administered the *same* cola drink at each of four trials. Thus, 15 got all Coca Cola, 15 all Pepsi Cola, 15 RC Cola, and 15 Vess Cola. In all other respects the procedure was the same as that of Part I.

Experiment II was suggested by the almost universal absence of the fourth cola name (Vess Cola) in the judgments of our Ss. Therefore, only three cola beverages were used in the second experiment. Ninety-six Ss were used in the first part; these were given three different one-ounce samples of each of the three following drinks: Coca-Cola, Pepsi Cola, RC Cola. In part II, 60 Ss were given three samples of the *same* Cola in counterbalanced order. In other respects the procedure was like that of Part I.

Results of Experiment I

Table Ia: Identification responses of 108 Ss to four different brands of cola drink.

Brand of Cola	Frequency of C.C.	Pep.	Identification R.C.	Vess	Responses Other	Total
Coca-Cola	46	34	21	1	6	108
Pepsi Cola	25	50	23	1	9	108
R.C. Cola	32	29	39	1	7	108
Vess Cola	29	34	29	1	15	108
Totals	132	147	112	4	37	432

Table Ib: Identification responses of 60 Ss to four drinks of either Coca-Cola, Pepsi Cola, R.C. Cola, or Vess Cola.

Brand of Cola	Frequency of C.C.	Pep.	Identification R.C.	Vess	Responses Other	Total
Coca-Cola	25	21	6	1	7	60
Pepsi Cola	27	21	10	2	0	60
R.C. Cola	19	20	14	2	5	60
Vess Cola	18	18	16	3	5	60
Totals	89	80	46	8	17	240

Tables Ia and Ib show the distribution of identification responses of both groups to administration of four different cola beverages. The data here show that regardless of beverage presented, there is a decreasing trend in frequency of response from Coca-Cola and Pepsi Cola as compared with RC and Vess, the last being rarely elicited.

Table IIa: Critical ratio tests of the frequencies of correct identification responses to four different brands of cola drinks. (obtained vs theoretical chance frequency)

Brand of Cola	Critical Ratio
Coca-Cola	1.64
Pepsi Cola	2.13
R.C. Cola	1.50
Vess Cola	.. ....

Table IIb: Critical ratio tests of the frequencies of correct identification responses when S was presented four drinks of one brand of cola. (obtained vs theoretical chance frequency)

Brand of Cola	Critical Ratio
Coca-Cola	.45
Pepsi Cola	.15
R.C. Cola	.00
Vess Cola	1.06

CRs of Tables IIa and IIb indicate lack of statistical significances between obtained frequencies of correct identifications and theoretical chance frequency. This would indicate that both when given four different

colas or four of the same colas, our Ss did not make discriminations on the basis of any taste properties of the samples.

Table III: Critical ratio tests to determine whether differences between percentages of successful responses when Ss receive four different colas and when Ss receive four drinks of the same cola are significant.

	BRAND OF COLA PRESENTED				
	Coca-Cola	Pepsi Cola	RC Cola	Vess Cola	Total
Per cent correctly identified when given different drinks	43%	46%	36%	1%	31%
Per cent correctly identified when given the same brand four times	42%	35%	23%	5%	26%
Critical Ratios	.33	.39	.25	1.49	.79

Table III further substantiates our findings, since CR tests here show that there are no significant differences in the percentages of correct responses between Part I (four different colas) and Part II (four samples of the same cola). Apparently, it makes little difference to our subjects what cola beverage or beverages they are asked to identify. Percentages of correct identifications are strikingly *similar* in the two vastly *different* experimental situations.

Table IVa: Identification responses of 96 Ss to three different brands of cola drink.

Brand of Cola	Frequency of C.C.	Pepsi	Identification R.C.	Responses Other	Total
Coca-Cola	39	26	22	9	96
Pepsi Cola	35	36	20	5	96
RC Cola	15	34	34	13	96
Totals	89	96	76	27	288

Table IVb: Identification responses of 60 Ss to three drinks of either Coca-Cola, Pepsi Cola, or RC Cola.

Brand of Cola	Frequency of C.C.	Pepsi	Identification R.C.	Responses Other	Total
Coca-Cola	27	20	9	4	60
Pepsi Cola	22	19	17	2	60
RC Cola	27	15	17	1	60
Totals	76	54	43	7	180

Results of Experiment II

Tables IVa and IVb show distribution of identification responses to presentation of these cola beverages for both groups. As in Experiment I, the RC identification apportionment of judgments of our Ss is not radically different whether three or four samples are used. This is indicated by a comparison of Tables Ia and IVa primarily.

Table Va: Critical ratio tests of the frequencies of correct identification responses to three different brands of cola drinks obtained vs theoretical chance frequency).

Brand of Cola	Critical Ratio
Coca-Cola	1.48
Pepsi Cola	.63
R.C.	1.48

Table Vb: Critical ratio tests of the frequencies of correct identification responses when S was presented three drinks of one brand of cola (obtained vs theoretical chance frequency).

Brand of Cola	Critical Ratio
Coca-Cola	.28
Pepsi Cola	.21
R.C. Cola	.61

CR tests reported in Tables Va and Vb, comparing obtained frequency of correct identification with chance frequency, fail to reveal significant statistical differences. This is interpreted to mean that our Ss' judgments are independent of the taste properties of the stimuli.

Table VI: Critical ratio tests to determine whether differences between percentages of successful responses when Ss receive three different colas and when Ss receive three drinks of the same cola are significant.

	BRAND OF COLA PRESENTED			
	Coca-Cola	Pepsi Cola	RC Cola	Total
Per cent correctly identified when given different drinks	41%	38%	35%	38%
Per cent correctly identified when given the same brand three times	45%	32%	28%	35%
Critical Ratios	.49	.77	.92	.65

Table VI compares the percentages of correct identifications of the three colas used in this experiment under conditions where 96Ss were presented three *different* colas and where 60 Ss were given three samples of the *same* cola drink. Despite the great differences in Part I and Part II of this experiment, nevertheless percentages of correct judgment are strikingly similar as can be readily observed by inspection of figures. Note that for Coca-Cola these percentages are 41 and 45 per cent; for Pepsi Cola 38 and 32 per cent and for RC cola 35 and 28 per cent. None of these differences is significant as indicated by the extremely low CRs of .49, .77, and .92 respectively. In other words, we appear to have a chance distribution in the application of any given cola brand name whether to three or four, same or different, brands of cola drinks.

Within the limits of the two experiments reported here, we believe that the results justify the conclusion that when our subjects were asked to discriminate and identify cola drinks, they might have done just as well by drawing their particular brand names out of a hat. Absence of any striking difference in the pattern of naming responses when three beverages are used instead of four, suggests that naming is more a function of familiarity with beverages through use and advertising media rather than a function of some chemical or physical property of the beverages themselves. If there are such differences, then our Ss do not discriminate them.

Remarks On the Mexican Subspecies of the Coral Snake *Micrurus nigrocinctus*

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Herpetological literature available to American students during the war years and immediately thereafter (1941-1947) indicated that the first notice of the occurrence of a subspecies of *Micrurus nigrocinctus* in Mexico was that of Schmidt and Smith (1943), who recorded *M. n. zunilensis* from high elevations (6,000 ft.), and *M. n. ovandoensis* from low to moderate elevations (400-1,200 ft.) on Mount Ovando, Chiapas. The previously-indicated upland range of *zunilensis* was confirmed by this record, while the distribution of *ovandoensis* was believed to be restricted to low elevations from Chiapas perhaps to Nicaragua.

In the same paper, Schmidt and Smith described another supposedly distinct species, *Micrurus browni,* from a low mountainous area (elev. *circa* 3,000 ft.) near Chilpancingo, Guerrero. Working independently, Mittleman reached the conclusion that *browni* was probably a part of the *nigrocinctus* complex, which was shortly thereafter demonstrated by Smith (1947) who reported *browni* from western Chiapas.

Actually, however, the occurrence of *Micrurus nigrocinctus* in Mexico was reported two years prior to the appearance of Schmidt and Smith's paper, by Mertens (1941), who described *M. nigrocinctus wagneri* on the basis of a single specimen from Finca Germania. Through the courtesy of the collector, Dr. H. O. Wagner, of Mexico City, we have been advised that Finca Germania is three or four miles northeast of Huixtla, in the municipality of Soconusco, Chiapas. This locality is roughly 20 miles southeast of Mount Ovando, and the type of *wagneri* was taken at an elevation of about 3,300 ft. in a zone of rain forest.

Mertens' coral snake may be characterized briefly as a *Micrurus* with black-tipped scales in the red zones; supra-anal tubercles in the male; 17 black rings on the body, plus six black rings on the tail; black rings two and one-half to three scales wide dorsally, two ventrally; yellow rings one-half to one scale wide dorsally, and obsolescent ventrally; red zones three to four times as wide as the black rings; black nuchal band six scales long on the vertebral line, and three ventrals wide on the belly; ventrals 205, caudals 52 (all divided); total length (in the only known specimen) 660 mm., tail length 112 mm.

A comparison of various characters of the four nominal Mexican races of *nigrocinctus* reveals differences adequate to support the maintenance of

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*Contribution from the University of Illinois Museum of Natural History.

all four forms, at least if the usual standards are accepted. Mertens' snake is readily separable from the other three races. To aid us in evaluating its status, we have been fortunate in having available some additional descriptive notes and photographs of the type, generously supplied to us by Dr. Mertens. From *M. n. ovandoensis* and *M. n. zunilensis,* the type of *wagneri* is immediately distinguishable by virtue of the prominent black pigment on the scales of the red zones. From *M. n. browni,* Mertens' snake is likewise distinct in that its yellow rings are narrower dorsally and obsolescent ventrally, and also because *wagneri* has fewer ventrals and black rings only two ventrals wide (as compared to three or four ventrals wide in *browni*).

Despite these differences, zoogeography does not clearly support the concept of distinctness of all four races. If valid, either *ovandoensis* or *wagneri,* or both, must have amazingly small ranges—amazing for coral snakes in this particular area which does not seem to have fostered the development of any reptilian forms with greatly restricted ranges. If the four nominal Mexican races of *nigrocinctus* are held to be recognizable, the only reasonable range concepts for them would be *zunilensis* at high elevations from Chiapaas southeastward; *wagneri* at low elevations (not coastal plain) from southern Chiapas southeastward perhaps to Nicaragua; *ovandoensis* at low elevations on and near Mount Ovando, and *browni* occurring at low elevations from western Chiapas to Guerrero.

Although the two known Mount Ovando specimens of *ovandoensis* are unique in possessing prefrontals which contact the supralabials, this is a character of dubious constancy, and there is little else to suggest the distinction of *ovandoensis.* Morphologically, there is considerable evidence pointing to the probability that only two races of *nigrocinctus* occur in Mexico, *i.e., browni* and *zunilensis,* and that *ovandoensis* and *wagneri* represent intergradant populations between *browni* and *zunilensis.* Neither *wagneri* nor *ovandoensis* possess characters intrinsically different from those of *browni* and *zunilensis;* they differ from each other, and from the two former races, only in their *combinations* of characters. Five morphological traits are involved, as shown in the accompanying table. One of the five (contact of prefrontals with supralibials) is of very doubtful constancy, so that actually only four factors are to be considered. The races *browni* and *zunilensis* differ in all four characters. However, *ovandoensis* agrees with *browni* in the dorsal width of the yellow rings, but is otherwise different; agreement between *ovandoensis* and *zunilensis* is seen in the number of ventrals, the ventral width of the black rings, and lack of black pigment in the red zones. Similarly, *wagneri* agrees with *zunilensis* in the number of ventrals, ventral width of the black rings, and

the dorsal width of the yellow rings, and differs from *browni* in all characters except the possession of black pigment in the red zones. The two forms *wagneri* and *ovandoensis* are essentially similar only in their ventral counts, and possibly the width of the black rings. Thus, it is seen that specimens of the nominal races *ovandoensis* and *wagneri* approach *zunilensis* closely in several respects, as might be expected in view of their greater proximity to the range of this form, and are presumably based on intergrades of *browni* x *zunilensis*. If the suggestion of the intergradient nature of *ovandoensis* and *wagneri* is correct, these names must become synonyms of *zunilensis*, since they are based on populations which more closely approach this form than *browni*.

Conclusions. We conclude that, while *M. n. browni*, *M. n. ovandoensis*, and *M. n. wagneri* may be considered distinct from *M. n. zunilensis*, there is a greater probability that only two races actually exist (*browni* and *zunilensis*), and that the names *ovandoensis* and *browni* are based on intergrading populations of *browni* and *zunilensis*. In the event that our surmisal is correct, *ovandoensis* and *wagneri* must be considered synonyms of *zunilensis*, which they most closely approach morphologically and geographically.

Table 1. Comparison of the Four Nominal Races of Micrurus nigrocinctus in Mexico.

Character	*browni*	*ovandoensis*	*wagneri*	*zunilensis*
Ventrals (♂)	210-224	204	205	196-207
Yellow rings, dorsal width	1½	1½	½	½
Black rings, ventral width	3-4	2-3	2	2-3
Prefrontal-labial contact	no	yes	?	no
Black pigment in red zones	yes[1]	no	yes	no
Vertical range	intermediate	low	intermediate	high

[1]Occasionally no.

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The Religious Implications of Jung's Psychology

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Dr. Carl Jung, with Dr. Alfred Adler, was a distinguished pupil and devotee of Dr. Sigmund Freud. After playing a leading role in the psychoanalytical movement for several years, this eminent Swiss psychiatrist withdrew from the Freudian group and founded his own school, known subsequently as the school of Analytical Psychology. The reasons back of this dramatic departure, while given no particular emphasis in this paper, will, nevertheless, be made somewhat apparent. Our particular concern, however, at the time is with the religious implications of Jung's psychology.

That religion occupies a paramount position in the psychology of Jung is evidenced from only a cursory reading of the literature. Indeed, as Dr. James D. Page of Temple University puts it:

> The Analytical Psychology of Jung is a mixture of keen empirical observation, mysticism, and religion.[1]

In this very brief consideration, it might be of interest and value to focus attention on Jung's concept of religion and its significance in connection with such Jungian emphases as mythology, the collective unconscious, the soul-concept, and psychotherapy. This may serve to point the way to a necessarily limited, but critical evaluation of such thinking.

In his book, *Psychology and Religion,*[2] Jung endeavors to make clear from the start what he means by religion. To quote him:

> Religion, as the Latin word denotes, is a careful and scrupulous observation of what Rudolf Otto aptly termed the "numinosu," that is, a dynamic existence or effect, not caused by an arbitrary act of will. On the contrary, it seizes and controls the human subject, which is always rather its victim than its creator. The numinosum is an involuntary condition of the subject, whatever its cause may be.[3]

Religion, Jung would go on to say, is the term that designates the attitude peculiar to a consciousness which has been altered by the experience of the numinosum. It should be emphasized that Jung does not attempt to prove the existence of a super-natural agent. He confesses that he cannot take this step psychologically. At the same time, Jung is concerned with the fact that men do hold to such beliefs, and he is interested in why they believe and the consequences that ensue.

According to Jung, spiritual concepts are indispensable constituents

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[1]James D. Page, *Abnormal Psychology,* (New York and London: McGraw-Hill Book Company, 1947)
[2]Carl G. Jung, *Psychology and Religion,* (New Haven: Yale University Press, 1940)
[3]*Loc. cit.*

of the psychic life. The spiritual aspect of the psyche is at present known to us only in a fragmentary way. Jung would say that what is significant in psychic life is always below the horizon of consciousness and when we speak of the spiritual aspects of the psyche we are dealing with things that are barely visible.

Jung emphasizes that contemporary man has spiritual tendencies engrained within his very mental structure because he has inherited such tendencies from the collective unconscious. It will be recalled that the collective unconscious is one of Jung's cardinal emphases. Man is the heir of all the ages by virtue of the collective unconscious. As Joan Corrie,[4] one of Jung's students, has put it, "It is the soil formed by age-long depostis of mental processes in which the roots of the psyche are deeply embedded."[5]

Primeval man, confronted by the stupendous forces of nature against which his puny strength was useless and surrounded by objects full of awe and mystery, apprehended his world in terms of spirit, energy, gods, demons, ghosts, dragons, etc. Such images imprinted in the brain substance evolved into sun and moon myths, vegetation myths, myths of gods and their deaths and resurrection, themes found everywhere among all people. These imprints Jung calls archetypes. Jung believes that these formations cannot be called a subjective psychic material, but that they are an objective psychic reality. These deepest images are experienced as the inner voice. Jung would insist that such images have a tempting force and are containers of dangerous energies. These images are to be treated with the utmost care for they are a nucleus for religious orientation. A positive value would be attributed to all religions, their symbolism, moral teachings, and ritualism being of strategic importance in relating the individual to inner psychic forces. In this respect, Jung would say that religious dogma represents the soul more completely than a scientific theory, the latter expressing and formulating the conscious mind alone, and, being primarily rational; while the dogma expresses an irrational fact such as the psyche. In speaking of modern man's predicament in this connection, Jung emphasizes the loss of carefully erected ecclesiastical walls, and contends that, due to this loss, man projects his own uncertainties upon his neighbor and, hence, the confusion and strife of the present time.

The psychotherapeutic value which Jung attributes to religion must be already evident. People have deep spiritual needs and aspirations. When those needs are not properly met, their lives appear empty and senseless. Jung would stress the importance of the directed life and urge

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[4]Joan Corrie, *ABC of Jung's Psychology,* (London: Kegan Paul, Trench, Trubner and Co., Ltd., 1927)

[5]*Ibid.*, p. 18

that it is religion which contributes to the discovery of life's meaning. To quote one of his classic statements:[6]

> During the past thirty years, people from all the civilized countries of the earth have consulted me. Among all my patients in the second half of life—that is to say, over thirty-five—there has not been one whose problem in the last resort was not that of finding a religious outlook on life. It is safe to say that every one of them feel ill because he had lost that which the living religions of every age have given to their followers, and none of them has been really healed who did not regain his religious outlook.

Time does not permit a careful evaluation of the religious implications of Jung's psychology. However, it stands to reason that Jung would find wider acceptance on the part of contemporary religionists than either of his former colleagues, Freud or Adler. According to reports, Jung is the recipient of particularly strong approval from British religious leaders. His de-emphasizing of sex, his stress of the psyche, and his convictions concerning the role of religion in the life of the individual would obviously win for him many devotees. Die-hard theologians and those who harbor rigid sectarian views might not always find solace in what he has to say.

On the other hand, the rather strong mystical flavor of Jung's psychology has frequently brought criticism from psychoanalysists and psychologists who have charged that Jung offers a challenging academic tutorship rather than an etiological therapy, "providing the neurotic individual," as Dr. Hendrick puts it, "with a new philosophy with which to cloak his suffering rather than a dynamic personality change and capacity for more mature development."[7] Thus, contrasting appraisals continue to be made with perhaps no one speaking the final word. Meanwhile, Jung remains as one of the great names in the field of psychology.

[6]Carl G. Jung, *Modern Man In Search Of A Soul,* (New York: Harcourt, Brace and Co., 1933)

[7]Ives Hendrick, M.D., *Facts and Theories of Psychoanalysis,* (New York: Alfred A. Knopf, 1934)

Observations On Constancy Of Color and Pattern In Soft-Shelled Turtles

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A remarkable pattern change observed in a specimen of *Amyda spinifera hartwegi* conant and Goin* kept in captivity for more than a year (1946-1947) is of considerable interest as an indication of the extreme extent of change possible under certain conditions, even in animals with normally constant patterns.

This specimen, a female, was captured April 28, 1946, by Mr. Lendell Cockrum in a small, clear stream north of Galena, Cherokee County, Kansas. Critical observations were not made upon the specimen at the time of capture nor immediately thereafter. Nevertheless, that it was more or less typical in color and pattern is assured by the fact that Mr. Cockrum, who has captured many specimens, observed nothing abnormal about it; he could not possibly have overlooked the peculiarities it possessed a year later.

The specimen was brought to the University of Kansas, and there was placed in a large, concrete tank provided with shallow water at one end overlying two or three inches of gravel and other material, while the other end was built up with a foot or more of sand and gravel which was above the water level. All natural light was excluded, but artificial light was available erratically. No special attention was thenceforth given to the turtle. While it was there, numerous other reptiles and amphibians were kept in the tank for periods of various lengths. Some of these died and decomposed from time to time, although no objectionable odor ever resulted.

The *Amyda* was not deliberately fed during the year it was kept in the aquarium. Some food was probably available as certain other animals died, but in spite of that meager source of food, the animal was in a starved condition. This was evident upon gross examination chiefly by the conspicuousness of the bones of the carapace.

The turtle was finally removed and examined carefully in June, 1947. The length of its carapace was then 180 mm. A thorough check revealed that the specimen unquestionably was the same one that Cockrum had released there more than a year before, yet its pattern and color were entirely different from what they were then.

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*We are much indebted to Mr. Lendell Cockrum for permission to study the turtle, which he collected; to Drs. A. B. Leonard, Carl L. Hubbs and F. R. Steggerda for various suggestions and assistance with experiments; of Mrs. Lila Miller for technical assistance; and to Mr. Roger Conant for his critical perusal of the manuscript.

The anomalous specimen of *Amyda* (see figs. 1, 2) was extremely dark above with faint indications of still darker lichenlike blotches which resembled to some extent the blotches of other occasional specimens as figured by Cahn (Univ. Ill. Bull. 35: 186, pl. 26, left, 1937) and Pope (Turtles U.S. and Canada: fig. 98, 1939). The ventral surface of the carapace was ringed by a series of small black blotches a short distance

Fig. 1. Dorsal view of a partially melanistic specimen of Amyda s. spinifera.

inside the periphery. A few other black or gray blotches were scattered elsewhere on the ventral surface of the carapace. A few scattered, tiny accumulations of pigment were distributed generally in the skin of the plastron and other ventral surfaces. At a deeper level in the hyoplastra, hypoplastra, and xiphiplastra, the dark material could be seen, somewhat

obscurely, deposited in a rather closely reticulated pattern, apparently within the structure of the bone. The dorsal surfaces of the limbs were extremely heavily mottled, and much pigment was present in scattered areas on the ventral surfaces of the forelegs and posterior surfaces of the hind legs. The ventral surfaces of the hind legs were lightly pigmented. The dorsal surfaces of the head and neck appeared to be little different from the normal condition, but their ventral surfaces were heavily reticulated and mottled.

Most specimens of *Amyda spinifera* are of varying shades of light tan above, often with very well defined, clearly outlined, small dark brown spots scattered more or less profusely over the carapace, or, in females, with poorly defined lichen-like patches of dark pigment. Except in very large specimens, the edge of the carapace is pale yellow. A narrow, dark line separates the pale border from the remainder of the dorsal coloration. This pattern becomes obscured in large adults which tend to be more or less uniform dull light brown above. The plastron and the ventral surface of the carapace are generally immaculate white or ivory; sometimes the plastral bones are darkened, and a ring of small spots may be present near the periphery of the ventral surface of the carapace.

Of great interest is the fact that much, if not all, of the dark material on the limbs and ventral surfaces of the entire body of the dark specimen was concentrated in the vicinity of blood vessels. The ring of pigment spots near the periphery of the ventral surface of the carapace corresponded closely to the position of the margino-costal vessels. Furthermore, examination of the skin under a hand lens revealed that the pigment appeared to be present in the vicinity of blood vessels, outlining their form and branches in some detail. In the webs between the toes, when examined under a compound microscope with transmitted light, most if not all of the blood vessels were clearly outlined by a black deposition in their walls bringing out in sharp contrast the entire complicated vascular network. Chromatophores were clearly visible by this means, imbedded in the skin in restricted areas indicated by the reticulated pattern. In other words, the peculiar color pattern of this turtle was then in large part simply the pattern of the peripheral circulatory system. Normal specimens examined in the same way reveal absolutely no outlining in black of blood vessels. The condition was clearly peculiar to the dark individual.

Several facts related to the coloration of the turtle deserve emphasis. The perivascular concentration of the dark substance; the lack of color change after six months in a clean aquarium in a well-lighted greenhouse; the occurrence of the color change under a condition of starvation in the dark; and in the presence in the original aquariam of large quantities of

the fine black material presumably organic in nature; all these facts suggest an exogenous color change in which carbon, iron compounds and other foreign materials might play a role.

Upon the turtle's death in December, 1947, an examination of

Fig. 2. Ventral view of same. Note depositions in bones of the plastron and in scattered spots near the midventer.

tissues from various parts of the body was undertaken with the hope of throwing some light on the nature of the extraordinary color change. Histological comparisons of all parts were made with comparable parts

of a more typical *A. s. spinifera* (male) from Illinois. As observed when the animal was alive, the pattern and color were found to be the result of (1) chromatophores and, (2) extra-cellular depositions. In addition, certain other non-chromatophoric cells were found to contain dark particles. Final analysis indicates that all of the dark matter was of endogenous origin, probably melanin or a pigment closely allied to melanin. Particularly in the carapace the pigment was seen in the form of rounded granules 0.5 to 1.0 micron in diameter and brownish in color as contrasted with carbon particles which are usually larger, irregular and quite black. The finer granules of this pigment were definitely brownish, although the larger clumps appeared black. It was soluble in sulfuric acid while carbon is insoluble in this reagent. It did not give the prussian blue

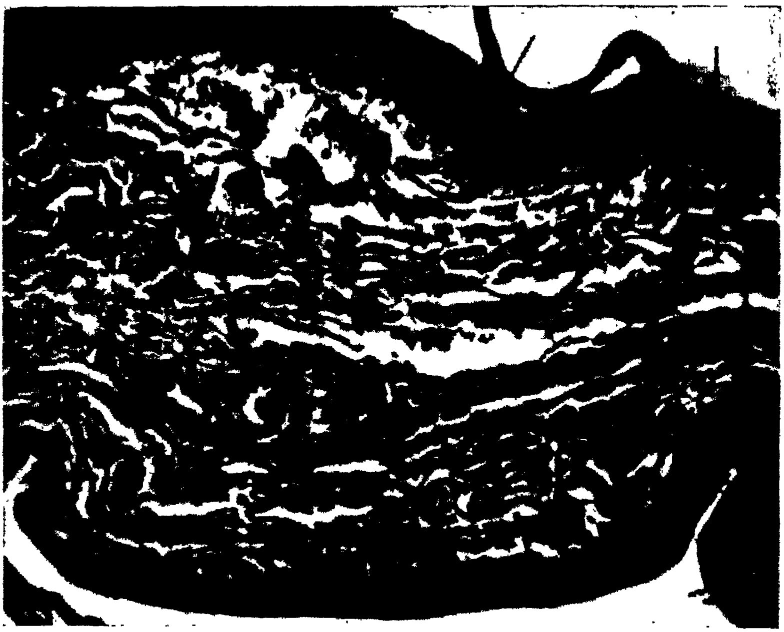

Fig. 3. Photomicrograph of web of same, from a stained section. The clumps of melanin can be seen concentrated about the blood vessels, six of which are in view and two indicated by black arrows. Chromatophores can be seen just under the epidermis. The nuclei, which are numerous in the epidermis and scattered elsewhere, are similar in appearance to the clumps of pigment but are more uniformly oval.

reaction for ferric iron, hence was not hemosiderin or hemofuscin. Its distribution in the tissues suggested an exaggeration of the normal mechanism of pigmentation rather than an entirely different mechanism.

The carapace of the abnormal specimen presented several aberrations. The stratum germinativum was only 2 to 3 cells thick as contrasted to a

normal of 3 to 6 cells. A granulosa cell layer was present in the normal specimen but could not be made out in the dark specimen. There was a very great increase in the amount of pigment present. This pigment was in the form of fine extracellular granules in the cornified epidermal layer of the dark specimen. The number of melanophores was increased in the dark individual and their distribution did not show variation corresponding to pattern. Perivascular pigmentation was accentuated; however, there was considerable pigment outlining the vascular bed in the normal specimen examined.

Sections of the skin from the web of the foot showed changes similar to those noted in the carapace but to a lesser degree. The granular pigmentation of the cornified layer was much less pronounced.

There was much pigment in the submucosa of the stomach, tending toward perivascular distribution. The pigment-containing cells were probably histiocytes. There was considerably less pigment in the normal submucosa but the distribution was about the same.

The cells of the parenchyma of the liver were hypochromic with granular cytoplasm. Along the sinusoids were many large, round to oval cells containing pigment granules. These cells tended to be in nests of 3 to 6. These pigment-cell nests were also seen in the normal liver. There were not so many nests per field but the groups tend to be larger (4 to 20 cells). There was probably little difference in the total amount of pigment present.

At least three explanations for the hyperpigmentation exhibited by the dark specimen are reasonably possible: (1) a metabolic disorder (perhaps in the metabolism of tyrosine or phenylalanine) incident of starvation and resulting in increased melanin production, atrophy of the integument, and concentration of melanin in the cornified layers; (2) an endocrine dysfunction as the primary cause of both the emaciation and the abnormal pigmentation; and (3) an example of the sort of delayed melanism that is regularly seen in such reptiles as *Heterodon contortrix, Pseudemys scripta elegans,* and *Crotalus h. horridus.*

The specimen of *A. spinifera* discussed in the preceding paragraphs was peculiar in another respect that may deserve mention: it lacked external evidence of the nasal ridges that are so characteristic of that and other species, as opposed to *A. mutica* which lacks them. It was obvious upon comparison, however, simply that the anterior portion of the internasal septum was lacking, and that the ridges themselves were lacking from the anterior portion of the remaining septum. These parts presumably were lost accidentally. The external nares were definitely not in the peculiar anterolateral position (as opposed to terminal), nor was the internasal

septum protuberant, as characteristic of *A. mutica.* Prominent tubercles, characteristic of *A. spinifera,* were present on the anterior edge of the carapace.

Summary

The patterns of soft-shelled turtles are indicated to be produced by two means: (1) chromatophores, responsible for the spotted pattern of the carapace and reticulated pattern of the limbs, and (2) other depositions, both intra- and extra-cellular, about blood vessels and in highly vascularized tissues located both superficially and deep. In one abnormal specimen of *Amyda spinifera,* exceptionally large quantities of non-chromatophoric pigment were present in various parts of the body, especially superficially and in the stomach wall. The deposition occurred during a period of 13 months while the specimen was kept in an artificial habitat chiefly characterized by the absence of light and the presence of a fine black organic material. The color pattern produced was fundamentally different from that of normal *A. spinifera,* reflecting as it did in detail the pattern of at least a part of the peripheral circulatory system. Probably the most reasonable explanations for the change are (1) metabolic disorders incident to starvation, (2) endocrine dysfunction, and (3) an anomalous case of delayed melanism. The same specimen, apparently through an accidental excision of the anterior portion of the internasal septum, lacked the specifically distinctive nasal tubercles.

Therefore: (1) even in species in which delayed melanism is not known, a pattern change of fundamental importance may occur at least as a result of metabolic disorders; and (2) ease of accidental loss of the nasal tubercles in *A. spinifera* and related species lessens the value of this character as a distinction from *A. mutica.*

The Growth and Development of Black Walnut (*Juglans nigra* L.) On Coal Strip-Mined Land in Southeast Kansas

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Black walnut trees established on coal strip-mined lands in southeastern Kansas 12 to 14 years ago are growing well, are producing viable seed, and are serving as good examples of the rehabilitation possibilities of these so-called waste lands. Kansas has more than 27,000 acres of stripped land that should be put to some worthwhile use. Since tree growing is one of the most promising uses of this land, the following information on approximately 2,000 acres of black walnut plantations in Crawford and Cherokee Counties, Kansas, is presented as evidence of what can be expected of this species.

A program for rehabilitation of lands stripped for coal in this area was developed in the spring of 1933. This work was activated by John W. Spencer, now Regional Forester, Region 2, U. S. Forest Service, Denver, Colorado, a native Kansan, in collaboration with many other leaders in the southeast Kansas coal field. From May 1933, through the summer of 1937, members of the Civilian Conservation Corps leveled or partially leveled the spoil banks on 3,400 acres of state-owned lands. Approximately 2,923 acres were planted with black walnut seeds. In a very limited area mixtures of other tree seeds and seedlings were planted with the black walnut.

The leveling of the banks with a bulldozer was the only ground preparation for the planting. This process resulted in fairly level areas in which are scattered depressions 4 to 10 feet in depth. Some of the depressions hold water throughout the year, forming lakes which generally support fish and other aquatic life.

The seed and tree plantings were made on all exposed ground except a strip 3 to 6 feet wide around the water surfaces. Black walnut seeds, obtained from native trees growing on riverbottom lands, were planted during the winter and spring months of each year from 1934 through 1937. The nuts were placed singly in holes, spaced 6 feet x 6 feet, or 6 feet x 8 feet, and were covered with 2 to 3 inches of "soil." Bur oak (*Quercus macrocarpa* Michx.) seeds, wild green ash (*Fraxinus lanceolata*

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[1]Paper presented at the meeting of the Kansas Academy of Science, April 29-May 1, 1948 at Kansas State Teachers College, Pittsburg, Kansas.

[2]Silviculturist, Northern Ozark Branch, Central States Forest Experiment Station.

Figure 1.—Black walnut trees on leveled coal strip-mined lands, November 1946. The hatful of black walnut seeds is the 1946 yield of the trees on a 1/5-acre plot. The trees on the same plot produced one bushel of nuts in the husk in 1947.

Figure 2.—View of the stand shown in figure 1, taken March 1948, immediately after 21 "crop" trees per 1/5 acre (28 per cent of the stand) were pruned.

Borkh.) seedlings dug from nearby woodlands, nursery-grown ponderosa (*Pinus ponderosa* Dougl.) and Scotch pine (*Pinus sylvestris* L.) seedlings, and bigleaf shagbark hickory (*Carya laciniosa* (Michx.) Loud.) nuts were, in a few places, mixed with the black walnuts.

According to the 1946 reconnaissance of the stripped lands by the Central States Forest Experiment Station, 2,000 acres, approximately two-thirds of the planted area, is now fairly well stocked with 300 to 600 trees per acre. The trees in these acceptable plantations average 14 feet in height, and 2.5 inches in diameter at breast height, and are typified by those shown in figure 1. The remaining one-third of the planted area should be replanted as conditions of the banks permit.

Most of the failed areas are relatively small, but a few large areas are scattered throughout the plantations. Although the exact causes of plantation failures on these specific areas are not known, the author believes that frequent wild fires may have been the principal cause on most of the relatively large areas. Several other probable causes of failure can be cited. The abnormally hot and dry summers of 1934 and 1936 were definitely unfavorable for the germination of seeds, and for the survival of seedlings. Improper planting, as well as rodent damage have also caused further losses.

Of these causes of failure, fire is one which can and should be controlled. Indications are that these lands have been burned over repeatedly. Most fires are set intentionally or through carelessness, and are therefore subject to control. With one exception no definite organized effort has been made to control fires in any of the plantations.

Although individual black walnut trees have continued to sprout after the tops have been repeatedly fire-killed, many are killed outright by one fire. Mortality is particularly high if the quantity of very dry fuel on the ground is great, and if the fire occurs during a period of low humidity and high winds. The control of fire is essential to the establishment of a satisfactory tree cover on extensive areas of these lands.

In May 1946 four permanent, circular, 1/5-acre sample plots were established in the successful black walnut plantations to study tree growth. Three of these plots are located near West Mineral, Kansas, in Cherokee County, and one near the entrance to the State Quail Farm, Crawford County. The number of tree stems on each plot by origin and species and estimated dates of planting are shown in table 1. A few natural seedlings, chiefly of white elm (*Ulmus americana* L.) have already become established in various places in these plantations.

Table 1.—Number of stems by species in each permanent plot and estimated date of planting

Plot No.	Black Walnut: Original stems	Black Walnut: Sprout stems	Black Walnut: Total	Bur oak	Ponderosa pine	Scotch pine	White Elm (Naturals)	Grand Total	Date Seeded
4	67	8	75	6	0	0	0	81	1935
5	84	41	125	0	0	0	0	125	1935
6	58	6	64	20	0	0	0	84	1936
7	45	4	49	0	26	6	5	86	1934
Average per acre	318	75	391	32	32	8	6	470	....

Measurements of the diameter at breast height and the total height of each tree were made prior to the beginning of the 1946 growing season, and again at the end of the 1947 growing season. In 1946 the treees averaged 1.95 inches in diameter, and 12 feet in height. In 1947 they averaged 2.45 inches in diameter and 14.2 feet in height (table 2). The average net increment per year was, therefore, 0.25 inch in diameter, and 1.1 feet in height.

Table 2.—Size and growth of black walnut trees on sample plots[1]

Plot number	Average d.b.h.: May 1946	Average d.b.h.: Nov. 1947	Average d.b.h.: 2-year growth	Average height: May 1946	Average height: Nov. 1947	Average height: 2-year growth
	Inches	Inches	Inches	Feet	Feet	Feet
4	2.8	3.0	0.2	16.0	17.0	1.0
5	1.1	1.8	.7	6.9	9.7	2.8
6	2.1	2.7	.6	13.0	16.0	3.0
7	1.8	2.3	.5	12.0	14.0	2.0
Average	1.95	2.45	.5	12.0	14.2	2.2

[1]The average yearly growth of the 63 trees of other species on these four plots was 0.2 inch in diameter and 1.1 feet in height.

Approximately 25 per cent of these walnut trees were designated as crop trees (110 trees per acre) and their size and growth rates were studied separately. Their average annual growth was 0.33 inch in diameter, and 1.58 feet in height. In the fall of 1947 they average 3.22 inches in diameter at breast height and 18.3 feet in height. Because of the position of these trees in the stands, and their more rapid growth rate, they are the ones that are most likely to remain in the stand and yield the higher grade products.

Although there are no similar natural or planted black walnut stands on nearby undisturbed land with which to compare these stands, their growth is considered quite satisfactory. If the growth can be maintained at approximately this rate, they should provide a worthwhile return.

The canopies of the plantations are just beginning to "close"; crowns of the trees are beginning to touch each other, and to completely shade the ground. Because of this shading the lower branches are dying, and through the natural process of pruning are dropping off, thus increasing the clear length of the stem.

Because of the wide spacing of trees in the plantations, this natural

Figure 3.—General view of the black walnut stand taken in March 1948, immediately following the pruning of the lower limbs from all trees by men employed by Kansas Forestry, Fish and Game Commission.

Figure 4.—A 1947 pruning wound and four sprouts that grew during the ensuing growing season. Photograph taken March 21, 1948.

pruning process is much slower than in most natural stands. Owing to the knots caused by persistent branches, a greater proportion of the volume of the merchantable tree stem will be of lower value than is the case in natural stands. To increase the amount of clear wood the Kansas Forestry, Fish and Game Commission is removing the lower limbs of all trees. On the average, about one-half of the live crown length is left on each tree. As shown in figure 3, this produces about an 8-foot lower bole, free of limbs, which should develop into at least an 8-foot sawlog or veneer bolt.

The removal of live limbs in open stands and the removal of too many live limbs in any stand may cause sprouting, particularly in vicinity of the pruning wounds. A typical example is shown in figure 4. In this case four sprouts developed around the wound during the first growing season after pruning. In stands with a closed canopy this type of sprouting usually does not result from this intensity of pruning.

In these plantations the pruning of selected crop trees is no doubt better than the pruning of all trees. This is being tested in three of the four study plots (figure 2). About 25 per cent of the trees in each of the three plots were selected as crop trees, and observations on the effects of pruning will be made for a number of years.

Viable seed has been produced by some of the trees in these stands for at least the past four years. Based on the yield from the four 1/5-acre plots, it is estimated that the 1947 seed crop was about 1.9 bushels of unhusked nuts per acre. This seed was well developed, and in every observable respect as good as that produced by trees growing in natural stands.

These plantations have been relatively free from serious attacks of insects or diseases. A forest tent caterpillar defoliates many trees in the late summer, but this is not considered very harmful to their growth and development. As yet no mortality due to insects or diseases has been observed in these plantations.

From these observations, and others made in connection with studies being conducted on the forestation possibilities of the coal strip-mined lands, it is evident that: (1) Black walnut stands can be succesfully established on certain of the coal strip-mined lands by the planting of black walnut seeds. (2) The trees started in this manner make satisfactory growth and begin to produce seed in eight years. (3) If properly managed the trees should yield logs and veneer bolts for the commercial trade in a reasonable length of time.

I. An Exploratory Study of Color Discrimination of Children

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Is color perception native? Is each individual born with a certain "capacity" or "incapacity" for discriminating colors or are these reactions built up during the person's psychological history in the same manner as his touch or taste perceptions?

An exploratory study by the authors throws some light upon this general problem and has opened up an interesting area for further investigation. The present paper is a preliminary report.

Procedure

Seventy-four children, ages 3-8, including 38 males and 36 females served as subjects. These were selected at random from the school population of Washington and the Wichita Day Nursery.

As test materials, the investigators used the Dvorine Color Perception Testing Charts but since it was felt that employment of all 60 plates would make undue demands upon the children, particularly in the younger age groups, it was decided to use only the charts on the left hand side. The rotating color disks were used for the color-naming part of the study.

Each child was taken into the experimental room singly and, after rapport was established, he was introduced to the rotating color disks and asked to name the eight dark hues presented one at a time. Presentation of the color charts followed after the subject was shown the easily discriminated Chart No. 1. *E* outlined the figure, 48, with a paint brush, turned the manual page to the first page of plates and said:

> "Now you paint the numbers you find in each of these plates one at a time all by yourself."

With three and four-year-olds who were unfamiliar with numbers, the instructions were modified as follows:

> "Follow the colored line you see inside (examiner pointing to the circle), or let's pretend that your brush is a car and the line in the circle is a road. Now let me see you follow the road all the way around."

The S was allowed to work at his preferred speed. When a discrimination error occurred, *E* required *S* to repeat the plate last successfully completed and make a second attempt on that plate. Failure of *S* to name the number correctly or to trace it throughout its extent, constituted an error.

Results and Discussion

As regards color naming, the data of Table I indicate certain trends that argue for a developmental explanation of color naming responses.

Table I.—Color Naming Responses of 69 Ss Between Three and Eight Years of Age

	Male			Female			Per Cent of Total Naming 8 Colors Correctly
Age	No. Ss	Number Correct Naming Responses	Per Cent Correct Naming Responses	No. Ss	Number Correct Naming Responses	Per Cent Correct Naming Responses	
3	3	0	0	2	0	0	0
4	4	1	25	4	1	25	25
5	8	1	13	8	2	25	18
6	9	8	88	9	6	66	77
7	9	8	88	9	9	100	94
8	5	5	100	4	3	75	88

The successive age groups from 3 to 8 show that the percentage of boys naming the eight colors correctly ranges from 0 at the youngest age to 100 per cent at 8 years. The same data presented graphically in Fig. 1 show a rather sharp separation between the groups of the pre-school ages (3, 4, 5) and the school groups, (6, 7, 8). These results suggest that the spurt in color naming responses is related to the child's entrance into the more formal learning situation of the first and subsequent grades. Certainly at the three-year level none of the subjects was able to label the various colors properly. Examples from our protocols show that red was called

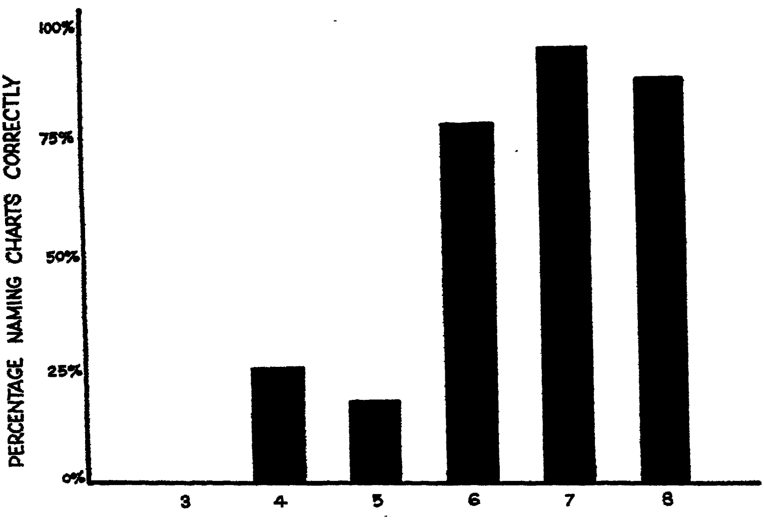

Fig. 1. Percentage of subjects of various age groups correctly naming 28 Dvorine plates.

brown, blue and pink, while blue was called red, purple, green, and black. Following age groups suggest a trend toward a gradual increase in effect-

iveness of color naming. Sex differences in color naming do not reveal themselves with any age group.

The main part of the experiment concerned the discrimination of colored figures (digits) upon backgrounds of different hues in a variety of combinations.

Table II.—Correct Discriminations on 28 Color Plates by 69 Ss, Four to Eight Years of Age

Number of Ss	Number plates correctly discriminated	Per cent of plates correctly discriminated
34	28	100
13	27	96
11	26	92
7	25	89
5	24	85
2	23	82
1	22	78

Results in Table II for subjects four years of age or older show that the particular color discriminations called for on this test are not an "either-or" affair. It should be noted that only approximately half our S's trace out all the digits and that the range extends down to 78 per cent of the total possible correct discriminations. Mention needs to be made of the conspicuous absence of three-year-olds here. It is interesting that none of the S's of this age group can trace out the Dvorine digits.

Further evidence for the specificity of color discrimination is given by the data of Table III.

Table III.—Discrimination of Dvorine Plates of Various Color Combinations by Age Groups (Per Cent Correct)

Plate Description: Figure (Digit)		Background	4 yr.	5 yr.	6 yr.	7 yr.	8 yr.
Red	—	Blue	100	100	100	100	100
Blue	—	Red	75	87	100	100	88
Green	—	Red	100	87	94	100	100
Red	—	Green	100	100	100	100	100
Red	—	Brown	100	100	100	100	100
Brown	—	Red	75	87	61	100	100
Yellow	—	Green	100	93	94	94	100
Green	—	Yellow	63	75	22	83	100
Yellow	—	Brown	100	93	100	100	100
Brown	—	Yellow	75	81	51	83	83
Blue	—	Orange	100	93	100	100	100
Orange	—	Blue	100	100	100	100	100
Blue	—	Violet	100	75	94	100	100
Violet	—	Blue	100	93	77	100	100
Green	—	Brown	100	93	100	100	100
Brown	—	Green	100	93	94	100	88

While the small sampling discourages a detailed analysis, there are trends that suggest that not all hues are equally discriminable, particularly

in certain combinations. Note that 100 per cent of four-year-olds discriminate a red digit on a blue background but only 75 per cent discriminate the reverse. Of six-year-olds, 94 per cent perceive a yellow digit on a green background, but only 22 per cent trace out the green number on a yellow background. This particular combination appears to be difficult for all ages but the eight-year group.

Table IV.—Percentage of 75 Ss Correctly Discriminating 28 Dvorine Color Plates

Age Groups	Total Population by-Sex: No. Males	No. Females	Number Discriminating 28 Dvorine Color Plates Correctly: No. Males	No. Females	Total	Percentage Discriminating Dvorine Plates Correctly: % Male	% Female	% Total
3	3	2	0	0	0	0	0	0
4	4	4	2	2	4	50	50	50
5	8	8	3	3	6	38	38	38
6	9	9	2	3	5	22	33	27
7	9	9	7	6	13	77	66	72
8	5	4	4	3	7	80	75	77

Additional light is thrown on this complex problem by the results shown in Table IV. As with the color naming reactions, so with the colored-digit-tracing responses there is an uneven but decided trend in the percentages of increasing age groups that are able to trace out the Dvorine numbers. It is significant that none of the three-year-olds can perform here. For the four, five, six, seven, and eight-year groups the percentages are respectively 50, 38, 27, 72, and 77 per cent correct tracing of the numerals.

As regards sex differences, Table IV also shows that at the three, four and five-year levels the percentage of both males and females discriminating the twenty-eight plates is the same (0, 50, and 38 per cent respectively). At the higher levels, males are generally superior with the exception of the six-year group, where the figures are 33 per cent for females and 22 per cent for males. At age seven, males lead with a figure of 77 per cent as compared with 66 per cent for females and at the eight-year level the males stand at 80 per cent vs. 75 per cent for females. Differences between the sexes are less than those within the sexes, again disagreeing with traditional theory. However, these results are more suggestive than conclusive and only further investigation with larger samples can yield any sort of definite answer to the questions raised here.

Summary and Conclusions

The present study utilized the rotating color disks and 28 color plates of the Dvorine Color Perception Testing Charts in an effort to explore color naming and color discrimination among 74 children, ages 3-8 and including 38 males and 36 females. It was found that:

1. Correct color naming was non-existent among our three-year-olds

and that generally pre-school and school groups were sharply separated in the direction of superior performance of the latter. There was no suggestion of sex differences here.

2. When Ss were asked to trace the digits on the color plates, the percentage of correct responses ranged from 78 per cent to 100 per cent of the total series of 28 plates.
   a. Apparently not all color-combinations were equally discriminable.
   b. The percentage of subjects making correct responses ranged from 0 at the three-year level to 77 per cent at the eight-year level.
   c. Sex differences within each group varied much more than between sex groups.
3. Larger samples are needed to settle conslusively the several problems raised.

Kansas Meteorite Discoveries 1873 - 1948

H. H. NININGER
American Meteorite Museum, Winslow, Arizona

In this list are all of the Kansas meteorites that the writer has been able to verify. Since 1923 the discovery of new meteorites has been one of our chief activities and a considerable portion of this activity has been applied to Kansas territory. Only 15 different falls were recorded for the state when this program of search was launched. To date we have been able to verify 54. Four more have been reported but the locations are so near to falls already recorded that it would be unwise to list them until critical comparisons had been made.

In this paper the word *fall* is used in designating each meteorite fall whether witnessed or not. A common practice has been to reserve this word for falls that have been witnessed and dated, whereas those unwitnessed falls were designated as finds. Obviously, each is a fall whether seen to happen or not. The distinction is easily made by following each name of a meteorite by the date of find or fall. For example, we write Beardsley, "Fell October 15, 1929;" and "Horace, Found 1940." Or, if we wish to emphasize the fact we may add "date of fall unknown." The point is that whether witnessed or not field notes should be made on each fall. A case in point is Ness County. This fall was discovered in 1897 and quite a number of stones were found shortly thereafter. Then there was a lapse of some 25 years after which we undertook a new search which brought to light some 40 more stones. There were many new finds but all belonged to the Ness County fall that had been discovered in 1897.

Incidentally, this new investigation brought to light one meteorite which could not be assigned to the Ness County fall that had been recorded. Its structure is entirely different. Consequently, it had to be given another name. Since its location data did not justify the use of any post office name we have simply called it Ness County No. 2.

The Haviland discoveries represent a somewhat different problem. Here, we were exploring the old Brenham, or Kiowa County, fall which is of the pallasite variety. We discovered a crater lined with oxidized fragments of the pallasite which we called the Haviland crater because the Brenham post office had ceased to exist and the crater was equally near Haviland which appears to be a permanent village. But we assigned the new find to the Brenham or Kiowa County fall of which it had evidently been a part — the main part, in fact.

Later, however, while exploring about the crater a small aerolite was found about one-half mile away. This bears no resemblance to any known part of the Brenham fall nor to the crater material. It evidently belongs to a different fall according to all accepted standards of identification. Consequently, we named it the Haviland aerolite.

Recently, Mr. H. O. Stockwell, by using modern detecting devices,

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has made a most important contribution to our knowledge of the Brenham fall. He has discovered a number of very fine pallasite individuals, some of which are very well preserved. Aside from the crater excavations, this is the first successful subsoil exploration ever made at the site of the Brenham fall. His work is a subject worthy of a special paper and I shall not attempt to deal with it here.

Those meteorite discoveries which have been definitely traceable to our program of field work have been marked with an asterisk. Some other finds have probably resulted from our work but we have not so designated them unless the fact was well demonstrated.

Kansas Meteorite Discoveries 1873 - 1948

Date	*Name*	*Type*	*Found*	*Fell*	*Weight*
1873	Waconda, Mitchell Co.	Stone	Found		50 kg. (110 lb.)
1881	Admire, Lyons Co.	Pallasite	Found		108 kg. (237.6 lb.)
1885	Brenham, Kiowa Co.	Pallasite	Found		3100 kg. (6840 lb.)
1886	Tonganoxie, Leavenworth Co.	Iron	Found		11.8 kg. (25.96 lb.)
1890	Farmington, Washington Co.	Stone		June 25, 1:00 p.m.	84 kg. (184.8 lb.)
1892	Long Island, Phillips Co.	Stone	Found		565.4 kg. (1243.88 lb.)
1893	Prairie Dog Creek, Decatur Co.	Stone	Found		2.9 kg. (7 lb.)
1894	Jerome, Gove Co.	Stone	Found	One Stone	29.8 kg. (65.56)
1895	Oakley, Logan Co.	Stone	Found		27.7 kg. (60.94 lb.)
1896	Ottawa, Franklin Co.	Stone		April 9	111 gr.
1897	Ness County,	Stone	Found		36 kg. (79 lb.)
1898	Saline, Sheridan Co.	Stone		Nov. 15, 9:30 p.m.	31 kg. (68.2 lb.)
1905	Modoc, Scott Co.	Stone		Sept. 2, 9:30 p.m.	30 kg. (66 lb.)
1906	Elm Creek, Lyon Co.	Stone	Found		.71 kg. (15.62 lb.)
1911	Cullison, Pratt Co.	Stone	Found		10 kg. (22 lb.)
1923	Anthony, Harper Co.	Stone	Found		20 kg. (44 lb.)
*1923	Coldwater, Comanche Co.	Iron	Found	One oxidized mass showing Widmanstätten fig.	18.4 kg. (40.4 lb.)
*1924	Coldwater, Comanche Co.	Stone	Found	Several stones	11 kg. (24.2 lb.)
1928	Lawrence, Douglas Co.	Stone	Found		515 gr.
1929	Beardsley, Rawlins Co.	Stone	Found	By Nininger. About 60 stones Oct. 15, 11:30 p.m.	16 kg. (35.2 lb.)
*1929	Covert, Osborne Co.	Stone	Found	Several stones	61 kg. (140 lb.)
*1929	Oberlin, Decatur Co.	Stone	Found	1910-11 Kept as handy weight about home	2591 gr.
*1932	New Almelo, Norton Co.	Stone	Found	Several stones	4.4 kg. (9.4 lb.)
1933	Gretna, Phillips Co.	Stone	Found		58.8 kg. (130 lb.)

Kansas Meteorite Discoveries 1873 - 1948

Date	Name	Type	Found	Fell	Weight
*1934	Ulysses, Grant Co.	Stone	Found		3.6 kg. (8 lb.)
*1935	Hugoton, Stevens Co.	Stone	Found	One stone	340 kg. (749 lb.)
*1935	Morland, Graham Co.	Stone	Found	Three stones	327.2 kg. (720 lb.)
1935	Pleasanton, Linn Co.	Stone	Found		2.2 kg. (5 lb.)
*1936	Elkhart, Morton Co.	Stone	Found	One stone	573.3 gr.
*1936	Grant County	Stone	Found	One incomplete stone, appeared fresh	2.3 kg. (5.6 lb.)
*1936	Seneca, Nemaha Co.	Stone	Found	Two stones	1.9 kg. (4.1 lb.)
*1937	Cedar, Smith Co.	Stone	Found	One stone	4570 gr.
*1937	Coolidge, Hamilton Co.	Stone	Found	One stone	4.5 kg. (10 lb.)
*1937	Haviland, Kiowa Co.	Stone	Found	1 stone found during detailed survey around Haviland crater	1033 gr.
*1937	Ingalls, Gray Co.	Stone	Found	One stone	226 gr.
*1937	Johnson, Stanton Co.	Stone	Found	Three stones	10.4 kg. (22.8 lb.)
*1937	Kensington, Smith Co.	Stone	Found	One stone	1585 gr.
*1937	Ladder Creek, Greeley Co.	Stone	Found	Many frag. found at plow depth in few sq. yds. of soil	35.1 kg. (77.2 lb.)
*1937	Ness County No. 2	Stone	Found	1 stone, found among stones of Ness Co. offered for sale by Ward's and rec. as distinct.	652 gr.
*1937	Waldo, Osborne Co.	Stone	Found	One stone	1.3 kg. (2.9 lb.)
*1938	Goodland, Sherman Co.	Stone	Found	2 complementary frag. found at bottom of 3 ft. post hole	3.6 kg. (8 lb.)
*1938	Nashville, Kingman Co.	Stone	Found		about 25 kg. (55 lb.)
*1938	Ransom, Trego Co.	Stone	Found	Several stones	15 kg. (33.1) lb.)
*1939	Pierceville, Finney Co.	Stone	Found	One stone	2.125 kg. (4.675 lb.)
*1940	Argonia, Sumner Co.	Pallasite	Found	(Recognized)	Est. 34 kg. (75 lb.) 84 gr. preserved
*1940	Brewster, Sherman Co.	Stone	Found		16.987 kg. (37.5 lb.)
*1940	Colby, Thomas Co.	Stone	Found	One stone	2.433 kg. (5.35 lb.)
*1940	Dwight, Geary Co.	Stone	Found	One stone	4.1 kg. (9.2 lb.)
*1940	Horace, Greeley Co.	Stone	Found	Two stones	9.2 kg. (20.3 lb.)
*1940	Otis, Rush Co.	Stone	Found	One stone	2.575 kg. (5.66 lb.)
*1940	Wilberton, Morton Co.	Stone	Found	Several small stones	207.5 gr.
*1944	Wilmot, Cowley Co.	Stone	Found	One stone, found by Nininger personally	2051 gr.
1948	Modoc No. 2, Scott Co.	Stone	Found	One stone	Unknown
*1948	Norcatur, Decatur Co.	Stone	Found	(Recognized)	3.18 kg. (7.01 lb.)
*1948	Norton, Norton Co.	Stone		Feb. 18, 5:30 p.m.	Unknown

Significance Of The Norton, Kansas, Meteorite

H. H. NININGER
American Meteorite Museum, Winslow, Arizona

All meteorite falls are important, but some are more important than others. When we look back through the years we note that there have been certain epochal meteorite arrivals, each of which punctuated the story of celestial visitors with more than a mere coma, or semi-colon. Some deserve exclamation points.

During the early years of man's acquaintance with meteorites, each new fall was regarded as an event and its particular composition or structure was simply another to be added to the glowing list of these extra-terrestrials. Then as the list grew, there gradually came to be certain types which were expected because they had made up a larger share of the total list than had other types. Finally, there developed certain fixed formulae of classification into which all meteorites must be fitted. This was only natural. It happens at a certain stage in the development of any young science. And it is a good thing, very useful as a guide in the proper study and cataloging of any new find. It serves as a frame-work into which to fit new discoveries.

Very naturally, after the materials of any category have been classified, there comes the temptation to analyze quantatively the various types and varieties. Such analyses are frequently sought after by scientists in related fields. This brings pressure from without and sometimes leads to premature conclusions on the part of those working within a new science.

This urge poses a partiularly dangerous threat to a science in which only a few men are working, because in such cases all of the workers in the small young science are likely to be lookeed upon as "authorities". (It would be a great safety measure for all scientists to learn the basic theme of my old professor, G. W. Stevens: "There are no authorities in science. Only nature is authority"). If any fall victim to this kind of flattery we are likely soon to have sacred boundaries established outside of which nothing is "valid".

About the turn of the present century, several attempts were made by various workers to determine the "average" or "general" composition of meteorites. Also, the relative abundance of certain structural characteristics. These generalizations were conveniently (if not very logically) based upon our museum collections of meteorites, which by that time had grown to include several hundred different falls.

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Viewed superficially from without, the study of several hundred meteorite falls might appear to be an adequate sampling of the crop, especially since it encompassed the work of a hundred years and took into account just about every valid specimen of a meteorite known to science.

Accordingly, these generalizations were accepted on good faith. They were snatched up and built into treatise after treatise where the general nature or insignificance of meteorites was desired or needed. Works on astronomy, geology, general science and all good reliable encyclopedias have, to a greater or less extent, incorporated the results of these researches.

As long ago as 1934, I pointed out the probable invalidity of all quantitative generalizations as to structure and composition of meteorites, basing my skepticism on the results of a protracted search for meteorites in several different areas of the Great Plains. Not only did I point out the lack of agreement between the results of our field search and the museum collections; but also that our experience in the tracing down of witnessed falls very strongly suggested that certain "rare groups" of meteorites were not in reality rare, but merely had not been found because of failure to recognize them.

Last February 18, 1948, there arrived in the vicinity of Norton, Kansas, a meteorite of epochal significance. This fall was of outstanding importance because with its arrival the entire picture of the word meteorite as portrayed in the total of collections throughout the world, was notably altered. This was true by virtue of two facts: 1st. It belonged to a very unusual variety of meteorites so far as man's experience was concerned; 2nd. The amount of material recovered from this fall was many times as great as all of the previously known falls of several varieties combined. Indeed, since the middle of August, 1948, when the largest mass of the Norton fall was brought to light, this previously rare type of meteorite has become one of most abundant to be found in collections.

It so happens that the sudden rise of a very rare type to an abundant rate also changes drastically the structural picture of the word meteorite. For now, instead of regarding the pegmatitic variety as a rare type, we must regard it as among the most abundant in collections.* This light colored mixture of fragmental and coarsely crystalline feldspathic minerals was known in collections, previous to 1946 by only two American falls,

*The Norton meteorite has been examined by the writer in the field and a few small fragments have been further examined in the laboratory. But in spite of the fact that he did all of the preliminary field work which resulted in its recovery, he has never received a sufficient quantity of the meteorite for analysis.

However, its general structure clearly places it in a class with the three falls of Bishopville, Cumberland Falls and Pena Blanca Springs. All of these are more closely related to terrestrial pegmatites than to any other of our earth rocks and are therefore referred to in this paper as the pegmatitic meteorites.

that of Bishopville, S.C. in 1843 and Cumberland Falls, Ky. in 1919. Together, these falls gave us less than 70 lb. of material. Then, in 1946, a mass of about 155 lb. arrived in west Texas and close upon its heels came the Norton fall of 1948, with more than a ton reported.

The most significant lesson to be learned from the Norton fall is not that of acquiring a new concept as to the structural and compositional character of meteorites, but rather the emphatic conviction that ***mankind is not yet qualified to develop a definite concept for the word meteorite, so far as structure and composition are concerned.***

For those who, previous to August, 1948, had familiarized themselves with the world's meteorites and who had carefully evaluated the facts regarding their structure and composition, as well as the conditions surrounding their fall and recovery, the word chondrule was certainly the most important in the meteoritical vocabulary as regards structure. This is still true, even since the Norton fall. But since that event the word pegmatitic holds a place second only to chondritic in that vocabulary. If, however, we have learned our lesson, we shall make no generalizations beyond our very limited knowledge of this subject. A score of other rare structural types could leap into second, third, or even first place overnight.

It is well to remember that all of the meteorites with which man has acquainted himself, either by their study in the laboratory, the museum, or even by means of meteoric spectrography, do not constitute the equivalent of one-fifty-thousandth of one per cent of the number which are encountered by the earth during a single revolution around the sun. A comparable rate of encounters has probably been experienced by our planet ever since its birth in the solar system. In the light of these well established facts, any attempt on our part to pretend to any considerable knowledge of the structure or composition of meteorites in our solar system is quite premature.

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Presidential Address
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Man's Disorder of Nature's Design in the Great Plains

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When man came to the shores of our continent he was confronted with an empire of great expanse and diversity. Animal life, including the American Indian, secured its subsistence mostly from native plants and animals. Our earliest settlers on the Atlantic Coast immediately began to clear the ground for cultivation, and as population moved westward, the practice of cultivating the soil moved likewise. It took many years, however, to reach the high plains of western Kansas. Wheat production seemed not to reach its maximum relative importance as a farm crop in the United States until it was grown on soils formerly occupied by prairie vegetation. This crop provided an ever increasing supply of wheat flour for making bread but "Man does not live by bread alone"—he needs a beef-steak occasionally. If man today were like Nebuchadnezzar of old, it would not be necessary for him to obtain by proxy his share of the vast amount of energy produced in the vegetation of our grasslands (Sampson, 1932). We have advanced beyond the stage of our ancient forefathers,

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*For a short biographical sketch of the author, see page 133.—*The Editor.*

however, and consequently we are confronted with the necessity of growing livestock in order to provide a portion of our daily diet. But livestock does not live by corn alone. It has long been recognized that the grasslands of America and elsewhere are indispensable to economic livestock production.

If grasslands are as indispensable as we have been told, perhaps it would be of interest to look into the origin of the prairies. According to authorities on the subject, many millions of years ago the area now occupied by the Great Plains was a vast body of water (Harvey, 1908). The marine fossils embedded in strata of limestone, under what is now the Great Plains, attest to this fact. From the close of Carboniferous time to lower Cretaceous time, the area was mostly land and occupied by certain types of ferns and conifers (Gleason, 1922). This type of vegetation evidently prevailed for many millions of years. During middle and late Cretaceous time the region was again invaded by a shallow sea, and following its withdrawal there occurred the uplift of the Rocky Mountains on the west. These mountains, according to authorities, intercepted the moisture laden winds from the Pacific Ocean and restricted the rainfall on the lands immediately east of them to moisture derived from the Gulf of Mexico. Gradual decrease in precipitation resulted ultimately in a grassy type of vegetation in this area. It is believed that this grassland type of vegetation has occupied parts of the Great Plains continuously for millions of years, and that vast arm-like projections of grassland have pushed out many times in several directions and withdrawn again when changes in climate occurred.

Millions of years after the formation of the mountains on the west, there occurred a series of events that exerted a significant influence upon the vegetation of the Great Plains. During the later Tertiary, gradual cooling of the climate in higher latitudes caused significant changes in the environment, which resulted in the disappearance of sub-tropical species of plants from north and west America. Apparently a distinct separation developed between the northern flora, predominantly gymnosperms, and the southern flora which was controlled by angiosperms. These two primarily arborescent types (in addition to the grasslands) have maintained their identity in North America since pre-glacial times.

As cooling of the higher latitudes continued, the Tertiary Period came to a close and it was followed by the period of glaciers. It is not the purpose of this paper to describe in any detail the cause nor the extent of glacial periods, but rather to consider briefly their effect upon the vegetation in the wake of their advance. As the ice moved down from the north there was started a migration southward of all living forms. Belts of

vegetative types such as tundra, bog scrub, coniferous forest and deciduous forest were usually maintained through the east and middle west as they moved southward. The width of each belt of vegetation, however, varied with topography. Farther west the treeless plains region was covered by prairie vegetation. This vast area of level land probably was bordered on the north by a broad belt of tundra.

With the retreat of the ice, the new bare glacial soil was naturally first invaded by the mosses and lichens of the tundra. After further retreat of the ice the climate became more suitable for plant growth, and

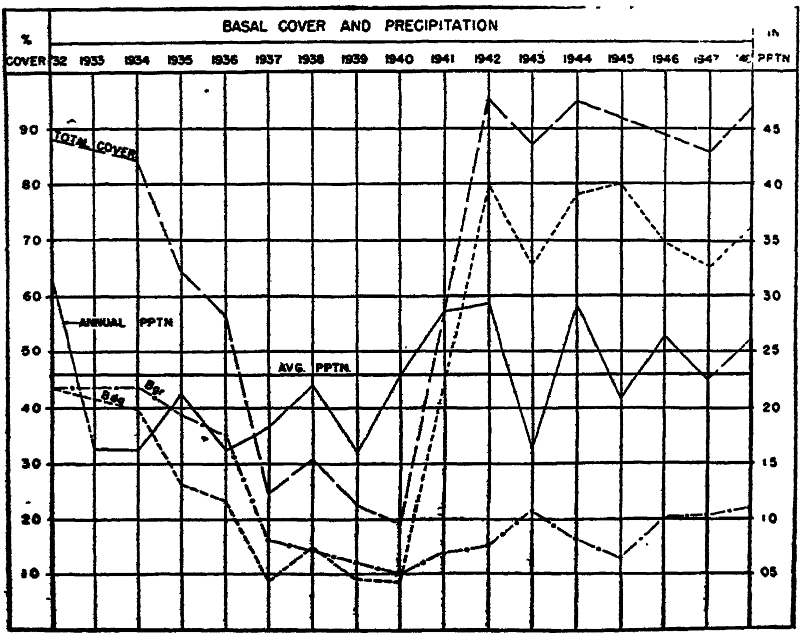

Figure 1. Average and annual precipitation, total percent basal cover and cover of blue grama (Bgr) and buffalo grass (Bda) on a well managed range at Hays, Kansas.

as a consequence, the belts of vegetation proceeded northward from the position which they occupied at the southernmost advance of the glaciers. In the east the succession northward was in the order of tundra, bog scrub, and conifers. The prairie grasses from the plains region, however, not only invaded the immediate adjoining tundra to the north but they also succeeded in penetrating the glaciated regions of the middle west. These grasses advanced slowly toward the east and northeast, proceeding as a wedge-shaped extension between the coniferous vegetation on the north and the deciduous forests on the south. The grasses apparently displaced the deciduous forests in the drier locations as far east as

Ohio (Woodard, 1924). One explanation of this unusual phenomenon of prairie succeeding the forest is that a xerothermic period began during the Wisconsin glaciation and persisted through the post-Wisconsin glacial retreat. Because of the dry period, the advance of the deciduous forest from the south was delayed, but the more humid grasses and their associates moved northward and came in contact with the prairie vegetation that moved in from the west. Thus the bluestems, the Indian grass, and the panic grasses came to be associated with buffalo grass, the grama grasses and other xeric forms from the west. This association evidently represents the farthest eastward general advance of the prairie vegetation of which we have any record.

At a later period, amelioration of the climate occurred which gradually ended the xerothermic period. As a consequence, the oaks, hickories, elms, ashes, cottonwoods, maples, etc., of the deciduous forests followed the retreating grasses in a westward direction. As the short grasses retreated westward, they took with them their "cousins" from the south, and upon their return to the high plains the more xeric grasses came to occupy the drier positions, whereas the grasses of the more humid south became established on the eastern border of the grassland formation and along streams and more favored positions westward.

There is no attempt here made to discuss in any detail the source of the material that went into the formation of the soils of the Great Plains except to mention in passing that some of the material was brought in by glaciers, some by winds, some by water, and some of the soils were formed in situ from existing rocks. Soil is not just a mass of inert mineral aand organic material. It must have both of these materials, but in addition if it is a good soil, it is necessary to have soil solution, soil atmosphere, and an abundance of soil organisms. The interaction of all of these constituents working through centuries of time has resulted in a soil that is one of the most fertile known to mankind. It was the interaction of climate, plants, and soils that brought plants and soils to their present native state of development.

The prairie vegetation is particularly well adapted to the production and protection of a deep fertile soil. The roots of many of our grasses penetrate the soil to a depth of five to eight feet depending in part upon species of grass and in part upon the type of soil in which they grow. Many of the broad leaved herbaceous plants such as wild alfalfa extend their roots somewhat deeper than do the grasses. Under these circumstances soil moisture and nutrients are secured from different levels reducing the amount of competition among the various species. There is considerable replacement of roots each year—the dead roots increasing

the supply of organic matter in the soil. Under good range management even the litter and debris on the surface gradually becomes incorporated into the soil.

In addition to being a first rate soil builder, a good cover of grass also ranks near the top as a soil protector. As the rain drops strike the prairie vegetation the force is broken, and the shattered rain drops run down the blades and stems of the vegetation where the accumulated water is held long enough for most of it to enter the soil. During downpours the clear excess water slowly runs away leaving the soil held firmly in place by the vegetation.

There is a close relationship between the type of climate, vegetation,

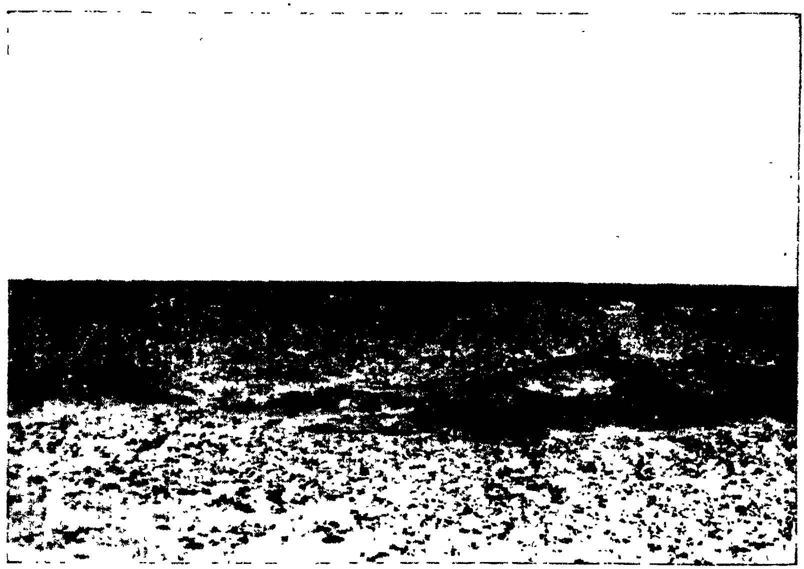

Figure 2. Mounds of drifted soil on an overgrazed range in southwest Kansas in 1939. Nearly all native vegetation was killed.

and soil found in any region and it appears safe to assume that to understand our climate we must understand our vegetation and the soils this plant growth produces. There is just one major reason why the grasses invaded as far east as Ohio in past geologic ages—it was climate. There is just one major reason why the forest did not replace the grasses in the high plains—it was climate. Thus we may study our native vegetation and predict with a considerable degree of accuracy the type of climate that produced the vegetation and the type of soil in which the vegetation is growing.

The herbaceous type of vegetation in the Great Plains is best adapted

to the extremes in climate that occur. Cycles of drought, hot desiccating winds of high velocity, prairie fires, tornadoes, hail storms and severe winters are all common to the plains region, but through all of these, the prairies have prevailed. There are times each season, however, when prairie vegetation does not receive sufficient moisture for growth, and therefore, much of it is forced into dormancy. The process of going into dormancy and out again may occur several times in one season; this is a common experience for the short grasses of the high plains (Albertson and Weaver, 1942). During extreme adversity in the past, our native prairies doubtless suffered greatly, but upon the advent of more favorable conditions, replacement of the former cover was rapid (Albertson and Weaver, 1944). Dust storms have been known to occur earlier than those that visited us during the '30's. The wind formed soils extending from the Mississippi Valley westward and covering much of northwestern Kansas illustrate this fact (Lyon and Buckman, 1943). Even during the last half of the nineteenth century our early settlers reported numerous "dusters" (Malin, 1946).

When the early explorers came through the plains region they found many of the plants that abound today in our native prairies; for example, Fremont in 1842 reports the presence of the following plants in or near Kansas:

Lead plant	*Amorpha canescens*
Willow	*Salix longifolia*
Prairie sage	*Artemesia spp*
Milkweed	*Asclepias tuberosa*
Thistle	*Carduus spp*
Sunflower	*Helianthus spp*
Buffalo grass	*Buchloe dactyloides*
Wild alfalfa	*Psoralea floribunda*
Sensitive briar	*Morongia uncinata*
Gaillardia	*Gaillardia spp*
Evening primrose	*Gaura coccinea*

The plants referred to by Fremont were doubtless important as a part of our prairie vegetation many centuries past.

The author of this paper remembers fairly distinctly the conditions that existed nearly 50 years ago. The vast majority of the land was native prairie. It was neither broken for cultivation nor overgrazed by livestock. The hilltops were occupied by short grasses and low growing broad leafed herbaceous plants. Many of the hills were dotted with bunches of little bluestem and in the favored areas such as buffalo wallows, side oats grama, and big bluestem were common. The hillsides were occupied primarily by big and little bluestem, side oats grama, Indian grass and panic grass. All but the little bluestem and side oats grama were dominant on the lowlands. At this time, most of the land

was open range and the livestock owned by the pioneers roamed as they wished along the streams and over the highlands. Occasionally small areas had been broken for cultivation. It is the change from the condition as it existed a half century ago to the present state that has become our principal difficulty. As the population increased, more land for cultivation was necessary. Increase in the cultivated area reduced the amount of native rangeland at a time when there occurred an increase in the number of livestock; hence a gradually increasing number of livestock was forced to graze on a gradually decreasing area of native rangeland. These effects have been the cause of at least two problems. The first

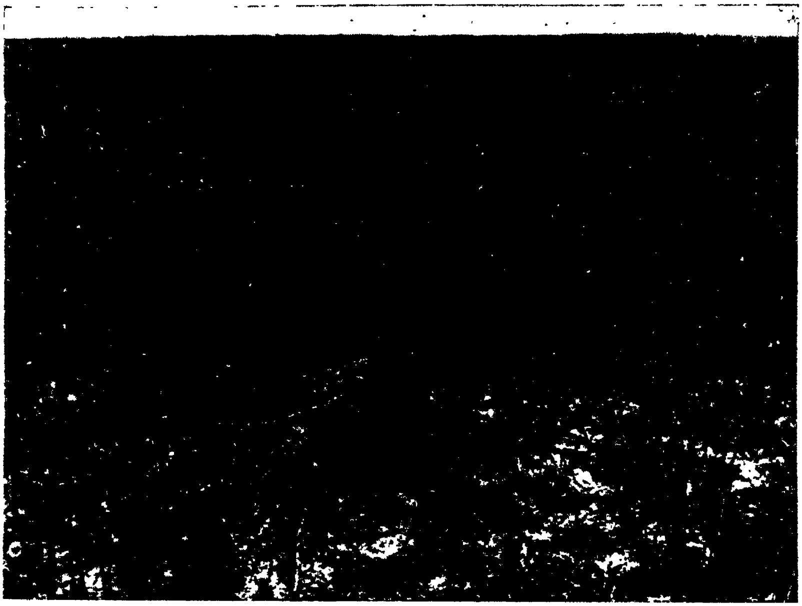

Figure 3. Same area as shown in Figure 2. Nothing but annual weeds were growing here when photographed in 1944.

is proper management of our cultivated land so that dusting of grasslands is reduced to a minimum. Research and leadership from our experiment stations and federal agencies have assisted greatly in bringing to our attention better methods for utilizing and conserving our cultivated soils. The second problem with which we are confronted is the proper management of our rangeland in order to secure maximum use with minimum of deterioration.

We have said that the native vegetation of the high plains is better adapted to the prevailing environmental conditions than is any other type of vegetation; that is why it is dominant. This statement does not

mean, however, that growth is luxuriant regardless of the season. During cycles of drought, it is only natural to assume that vegetation would adjust itself to drought conditions. Increment of growth during dry seasons would naturally be less. Seed production would be gradually decreased as would also basal cover. Even root development would doubtless be modified greatly. Recovery, however, would occur over a relatively short period of time. The greatest destruction of our rangeland has occurred when the impact of over utilization of rangeland and poor tillage practices of our cultivated soil have been added to the impact of unfavorable climatic conditions. The early pioneers were not confronted with over

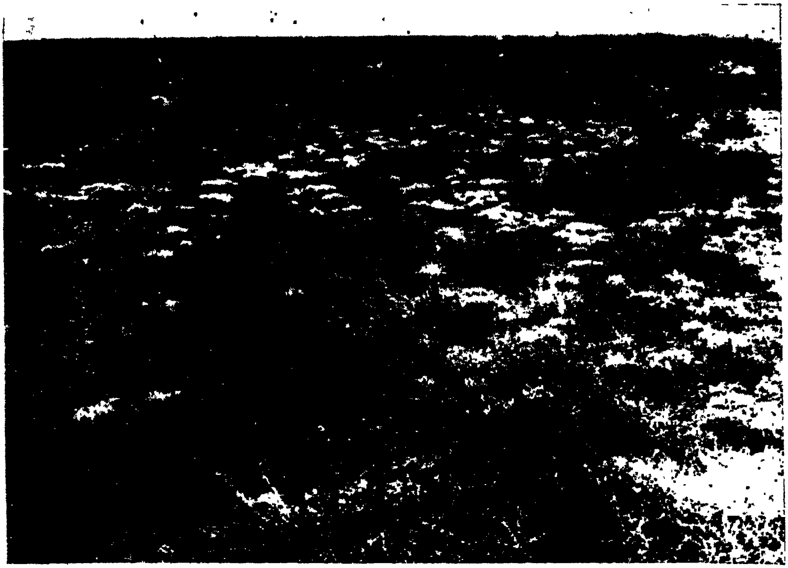

Figure 4. Range near Winona, Kansas in spring of 1941. Blue grama and buffalo grass (light areas) comprised 5 percent of cover of native vegetation. Remaining part of area was bare or occupied by annual weeds.

utilization because, as grass became scarce in one area, the livestock naturally moved to another area on the free range where utilization had been less intense. Under these conditions it was only natural to draw the conclusion that grasslands were not expendable—that they came into existence through a long period of adversity and nothing that man could do would destroy them.

Research on rangeland in the Great Plains has been limited mostly to the present generation; in fact, most of it has been done during the past twenty years. Several members of the botany staff of Fort Hays Kansas State College claim western Kansas as their "native habitat". They have

watched the prairies gradually deteriorate under the influence of over utilization, or have seen their complete destruction as they were put under cultivation. It, therefore, became obvious that more information was needed in order to know more fully how we might maintain our prairies under high production at the same time they were being utilized by livestock and, more recently, how to regrass much of our worn out cultivated land. In the late '20's and early '30's a program of study was initiated at Fort Hays State College and has continued unbroken since that time. Fortunately from 1927 to 1932 inclusive, precipitation at Hays and at other locations in the high plains was considerably above normal. This

Figure 5. A well managed pasture in 1939 at Dighton, Kansas. The cover of blue grama and buffalo grass was 20 percent.

condition made it possible to lay out research and to obtain initial data at a time when our prairies were at a maximum of development. Areas were set aside in 1932 in order to determine what and how much vegetation occupied different topographic locations (Albertson, 1937). More recently, other studies have been inaugurated throughout western Kansas, particularly in the southwest (Albertson, 1941, 1942). Many of these areas have since been plowed up and planted to wheat—a practice that has been going forward at an alarming rate in western Kansas and eastern Colorado during the past few years.

Research on the prairies during past years has revealed some striking

facts. The first significant reaction of prairie vegetation to drought is decreased growth. As drought continues and becomes more intense, that portion of vegetation least adapted to adversity dies thus leaving an open cover. Further drought adds to the openness of the cover until finally runoff of rain water is materially increased, causing soil erosion and further depletion of soil moisture. This cycle of events continues to make the situation more and more critical, especially if deficient precipitation extends over a long period of time and over a large area. When the

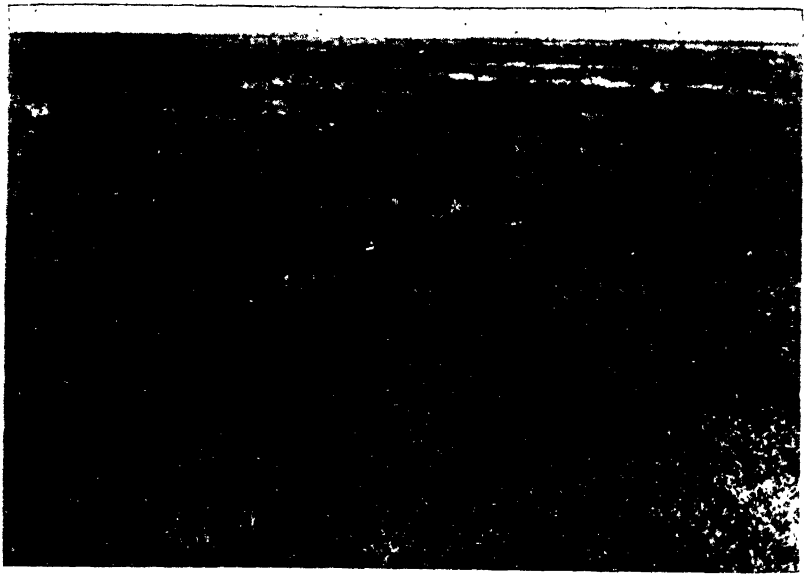

Figure 6. Same area as shown in Figure 5. Replacement of cover was nearly complete in 1942.

effect of over utilization is added to that of drought, the result, indeed, is very significant.

A few figures on cover and yield in relation to degree of utilization and amount of precipitation might be used to illustrate this principle. In 1932, which was the close of a six year period of above normal precipitation, the basal cover on a well managed short grass pasture averaged nearly 90 percent of the total area (Figure 1). The decrease in precipitation following 1932 was extremely abrupt but it took two years of drought to produce a significant decrease in the cover, and by 1937 the blanket of vegetation had been reduced to 25 percent, but in 1940 when the drought closed, the cover was only 20 percent. With the return of sufficient soil moisture the cover was quickly restored because of the phenomenally rapid growth of buffalo grass.

On an adjacent heavily grazed range, the lowest cover of 2.6 percent was reached in 1936. In various locations in southwest Kansas where dusting and utilization were severe, the last vestige of vegetation was often removed and even today some of the rangeland has the appearance of weedy cultivated fields (Figures 2, 3, and 4). Other ranges in southwest Kansas that were more fortunate in regard to degree of utilization and dusting have long since regained their predrought cover (Figures 5 and 6).

The question often asked is "How much do short grass pastures produce each year?" Obviously there is no *one* answer. Production of

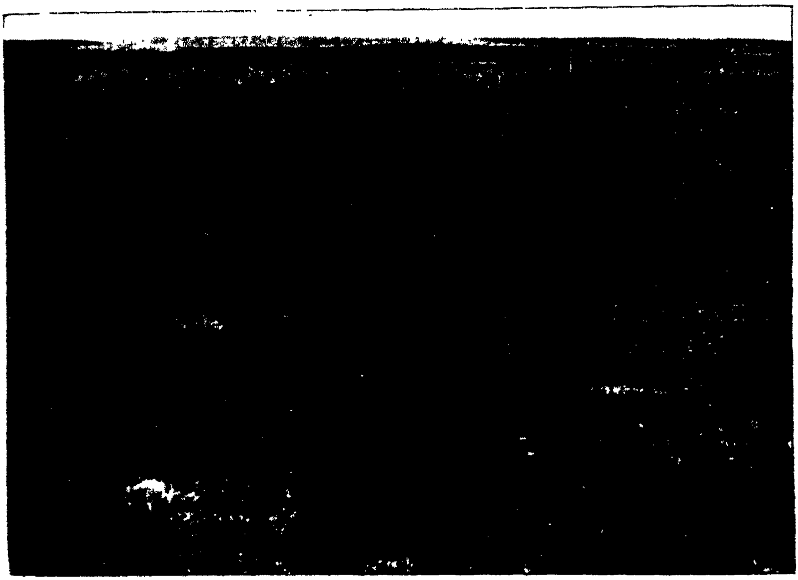

Figure 7. A well managed range in 1946 at Ness City, Kansas. Yield of grass was 1800 pounds per acre.

grass usually varies directly with amount of soil moisture and inversely with production of weeds. It should be stated that a cover of weeds is preferable to no cover, for weeds protect the soil from erosion in addition to furnishing considerable food for livestock. In 1940 a number *one* pasture at Hays yielded nearly 1400 pounds per acre of grass but only 400 pounds per acre of weeds (Albertson and Weaver, 1944). A poorly managed pasture produced only 133 pounds of grass per acre but the weed crop was over one ton per acre. Farther west than Hays there were fewer good pastures and in 1940 even the best of these yielded less than 200 pounds of grass but nearly 1500 pounds of weeds.

In 1941, the best pastures at Hays increased in yield considerably but

those westward often increased tenfold or more. The poor pastures, however, failed to make significant gains except in the production of weeds. It seemed evident, that when a remnant of vegetation remained at the close of drought, restoration of cover was extremely rapid and the yield for some time after restoration even exceeded that on the better pastures where the cover suffered less during drought. Possibly this result was due in part at least to a more vigorous new cover on a soil that had rested for a few years.

In 1946 a well managed pasture at Ness City, Kansas, yielded 1800 pounds per acre but a nearby heavily grazed area produced only half

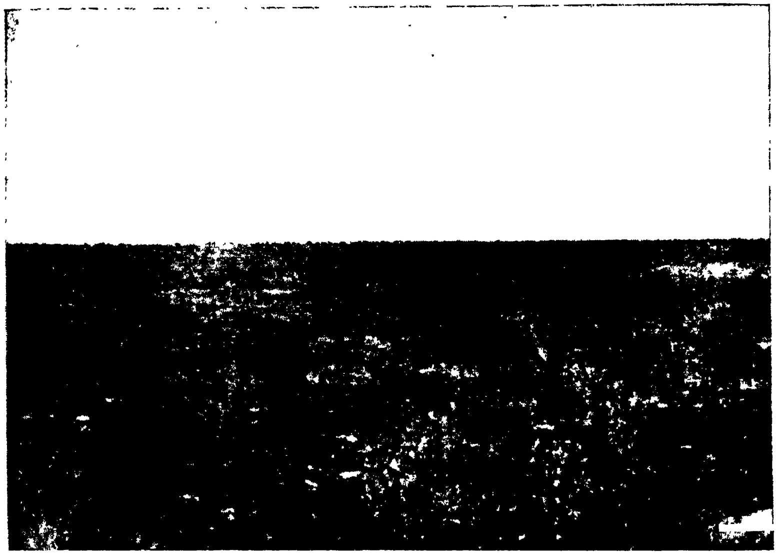

Figure 8. A heavily grazed range in 1946. Located within one mile of the pasture shown in Figure 7. Yield of grass waas 900 pounds per acre.

this amount (Figures 7 and 8). Five areas near Collyer, Kansas, were studied during the summer of 1946 (Tomanek, 1948). These ranges differed mainly in the intensity of utilization during fifteen years preceding the period of study. The ungrazed pasture produced approximately 2500 pounds per acre as compared to 4000 pounds on a well managed range and only 1800 pounds on a heavily grazed area. These data indicate that heavy utilization reduces the yield by 50 percent and that grazing too lightly also decreases production.

A 5-year study on a short grass pasture near Hays was initiated in 1942 to simulate different intensities of grazing by clipping at different heights and at different intervals. It was discovered in this study that approximately 50 percent of the grass could be left on the area and in

5 years the amount removed from these locations nearly equalled total production on the areas where all growth was harvested. Root develpment under these treatments also was significantly different. Roots under non-use and moderate use were nearly the same, but under heavy clipping the roots were not only finer and less in number per unit area but also their depth of penetration into the soil was significantly less.

Life histories of important grasses of the Great Plains have been studied in order to know the best sources of grass seed for reseeding cultivated land (Riegel, 1941; Webb, 1941; Hopkins, 1941). It seemed wise to revegetate some 500 acres of cultivated land on the College Farm, and while doing this, basic studies have been made on methods of seedbed preparation, methods of seeding, rate of growth and yield (Riegel, 1940).

In order to properly manage our rangeland, it seemed desirable to have more information on the time of the season when growth occurred. It was surprising to some to find that as much as 70 percent of the total growth in one season occurred before July 1.

Numerous studies indicate that cattle, for example, enjoy variety in their range diet just as human beings prefer variety in theirs. A closely cropped pasture of nearly pure buffalo grass is entirely too monotonous in appearance and in palatability to be of greatest value in beef production. Over utilization has been found to decrease the number of desirable species in a native range.

Dormant prairie forage is low in succulence and usually low in protein content, hence good rangeland should have at least some green herbage throughout the growing season. The chemical composition of prairie grasses has been found to vary significantly especially in early spring as compared to late fall.

It is well, perhaps, to brings this paper to a close by pointing out the fact that what has been done on the prairies at Hays and elsewhere, may serve only as a foundation for greater and more detailed work. These investigations on the vegetation of the mixed prairie and high plains are most refreshing both to the college instructor and to the college students. An opportunity is provided to take the student to the prairie or, when this is impossible, the prairie is taken to the student through exhibits of one type or another. It is hoped by this means to bring together the great out-of-doors on the one hand and the student of nature on the other.

The vegetation of the Great Plains, a vast area of reserve sunshine, of potential beefsteak, of exquisite beauty has slowly come to us through past ages, and from what we know at the present time these prairies are best preserved through moderate use. The cover of vegetation that is used

to build and protect the soil approaches a maximum under moderate use. Also a maximum yield of first class herbage is thus provided and, finally, there is preserved the beauty in the ever changing panorama of flowers and color of foliage from one aspect to another as each season progresses.

Nature, indeed, has designed in our prairies a most wonderful soil builder and soil protector. It is necessary, of course, to cultivate the most level portion for the production of wheat and other cereals. When cultivation is practiced, however, it should be done in such a manner that high productivity of the soil may be maintained. There are vast stretches of native prairie that have been put under cultivation during recent years. Some cultivation has been practiced on areas of broken topography where erosion is likely to become serious in a few years.

One of the major problems that is now confronting the farmer of western Kansas is how best to reseed to native grass a portion of his land under cultivation. If an adequate supply of grass seed and seed of other plants can be maintained and if techniques of seed bed preparation and reseeding can be improved, it might be possible eventually to grow native grass in a long time rotation.

It should be the policy of all who live and work in the plains region to learn more of its proper use and, at the same time, how to preserve its beauty. We must have bread made from its wheat but also we should enjoy its beauty—for "man does not live by bread alone."

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The Editor's Page

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ROBERT TAFT, *Editor*

The editor realizes that there are a number of individuals among the scientific profession of the state who, if they do not regard the Academy with outright contempt, at least do regard it with so benign a condescension that all working members of the Academy should rejoice and praise God that the great ones of the scientific world recognize the humble existence of the Kansas Academy of Science. Fortunately, the number of such condescending individuals is not large. By far the larger proportion of the scientific profession in the State are members of the Academy and many take an active part in its affairs—as was evidenced by the hundreds who attended the annual meeting of the Academy recently in Manhattan.

The Academy has had a long, honorable, and useful history and has played an important part in the cultural and economic development of Kansas, a fact that is borne in upon the editor the more familiar he becomes with the history of the state. Quite recently, while making a literature search for a project in which he is currently interested, your editor encountered a direct reference to the *Transactions* which illustrates and emphasizes the point made above. The account was written by W. H. Russell, a celebrated correspondent of the London *Times*. Russell made a number of trips to the United States at various times and his correspondence attracted attention abroad and especially in this country; for Russell was blunt and outspoken and his writing frequently drew angry fire from the American press. What he reports concerning the *Transactions*, therefore, has an added significance.

In the summer of 1881, he accompanied the Duke of Sutherland and a considerable party on a transcontinental tour of the United States. His letters to the London *Times* describing the trip were subsequently collected and published separately. Among these letters is one written as the party traveled on the Santa Fe through Kansas. The letter reads in part:

> June 19, 1881. It would be ill done, when I am anxious to acknowledge the pleasure and profit which I derived from my passage through the State, if I did not record the satisfaction with which I perused a volume of the *Transactions of the Kansas Academy of Science*, which by accident I picked up at one of the stations [Newton]. The very name speaks trumpet-tongued for the progress which has been made in this wild region. The year before last, the twelfth annual meeting of the

Academy was held in Topeka, and I find amongst the list of papers read such subjects as these—The Kansas Lepidoptera, Kansas Minerals, The Mounds of Southern Kansas, Recent Additions to Kansas Plants, Kansas Botany,. Kansas Meteorites, Phonetic representations of Indian Language, Sinkholes, Elementary Sounds of Language, Mound-Builders, On Recent Indian Discoveries, and among the lecturers there was Professor B. F. Mudge, who died last year, whose name probably is known to a very limited number of scientific men outside the University of Kansas. Generally the papers contributed by the gentlemen of the state attest industry and attainments which make their praise of the Professor particularly valuable. It is curious enough to pick up in a railway carriage, traversing such a scene of comparative wildness and vast uninhabited plains in Western Kansas, an exceedingly interesting examination of the Helmholtz theories of sight — Althogether these papers give an impression that in this new State there are diligent students of natural history and physics, and profound inquirers into all the phenomena of life.

Although Kansas of 1881 could only be called "a wild region" by an inhabitant of a much older civilization, Russell's interesting commentary should lend added heart and strength to Academy members of the present day in their attempt to maintain the traditions and standards of an important and useful society.

Dr. Fred W. Albertson, the immediate past president of the Academy, whose presidential address appears as the feature article in this issue of the *Transactions*, owes his interest in the Great Plains to the most natural of reasons. He was born in Hill City, Graham County, on January 1, 1892. For those unfamiliar with Kansas geography, Graham County is in the northwestern quarter of the state about a hundred miles east of the Kansas-Colorado border and well within the region which we call the Great Plains. His early experiences were typical of boys who lived on the Great Plains of that day: he attended school in a sod school house when the elementary schools of Graham County were irregularly held, 65 days in one year being unusually long; with his twin brother, he herded the family cattle on the western prairies; and he hunted and fished—when there was water—on the wide open spaces. His mother's keen interest in flowers, together with the environment in which he lived, decided Dr. Albertson's career. An inner urge—there seems to be no better word for it—kept him on his scholastic way, for usually fifty years ago by the time a youngster in western Kansas reached the level of the eighth grade, his education was complete. But Dr. Albertson taught three terms in the rural schools of Graham County and, during the spring and summer months, he continued at the "academy"—a high school we would call it now—in Hays and finished the four years of college work offered by the Hays Normal School, now known as Fort Hays Kansas State College. A master's degree in agricultural education at the University of Missouri followed and eventually a doctor of philosophy degree in botany under Dr. J. E. Weaver at the University of Nebraska was attained. He joined the staff at Fort Hays in 1918, and, save for leaves of absence, he has been associated with our westernmost college since that time. In

1937, he became professor of botany and chairman of the graduate division at Fort Hays. His many contributions to our scientific knowledge of western Kansas and the Great Plains are reviewed in part in his excellent and interesting presidential address.

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

The attention of Academy members is directed to the fact that beginning with this issue of the *Transactions* we carry in the section immediately following this one, the column "Junior Academy News." It is hoped that this column will stimulate interest and activity in the work of the Junior Academy. All Academy members are urged to lend their support to this new undertaking by reading the column (which will give some idea of the activities of junior members), by contributing suggestions and by aiding the sponsors of local junior groups. The additional effort required will, we hope, show results in years to come.

Dr. Charles Michener, associate professor of entomology in the University of Kansas, Lawrence, is working under a Navy grant on the study of the life history of trombiculid mites, commonly known as the chigger. Associated with Dr. Michener are graduate students Richard Loomis of Perry, Kansas, and Louis Lipovsky, Barberton, Ohio. Studies are being made of the relationships of chiggers to host animals, to insects upon whose eggs they feed, and to the soil environment in which these mites live; for, strictly speaking, chiggers are mites and not insects. These mites are all too well known to many generations of Kansans and as the chigger season is upon us, the following information from Dr. Michener will be of interest and may be of help.

Chiggers create their "bites" by injecting a substance into the skin of the host with the result that some skin tissue is liquefied and consumed by the mite. The skin injury and not the burrowing of the chigger into the skin, a common fallacy, remains as a source of irritation to the host animal. It is only the young, six-legged larval chigger, that bites. These young animals climb blades of grass, bushes and leaves and attach themselves to passing animals or humans. Each chigger bites but once and, having fed, drops from its host and develops into an eight-legged nymph which subsequently molts to become an eight-legged adult. Nymphs and adults live in the soil, are incapable of biting, and live on eggs of certain small soil insects. Three species of chiggers are known in the United States that attack humans and many other species that do not.

For protection against chiggers, Dr. Michener recommends that stockings, and the lower part of trousers or dresses be treated with a five percent emulsion of dimethyl phthalate (sold commercially as

Skat) or with liquid (100%) benzyl benzoate. The latter may be sprayed on, or the clothing may be dipped in the emulsion and then allowed to dry. Chiggers coming in contact with either substance are killed, the protection remaining until the clothing is washed.

It has also been found in some parts of the country that a lawn or area infested with chiggers may be dusted with benzene hexachloride (available from insecticide dealers) for the destruction of the mites, the protection lasting for several weeks or months. Three pounds of the dust (figured as 100% benzene hexachloride) are required for a lawn 25 by 50 feet. Dr. Michener would welcome reports from any who try the above method as there are no records of results in Kansas. Other and more economical methods for control of the mites are under study at the University.

We report with regret the death of Dr. H. H. King on March 12, 1949, who retired last July as chairman of the department of chemistry of Kansas State College, Manhattan. Dr. King, a member of the Academy since 1909, joined the staff of Kansas State as an assistant instructor in 1906 and worked his way successively through the ranks until he became head of the department in 1918. He was born at Ewing, Illinois, on Feb. 28, 1883, and received his education at Ewing College, Kansas State College, and the University of Chicago where he received his doctorate in 1918. Dr. King's special field of interest lay in soil and surface chemistry, some of his papers in this field appearing in these *Transactions*. He was also greatly interested in intercollegiate athletics and for many years served as representative of Kansas State in the Missouri Valley and Bix Six athletic conferences.

The department of entomology at Kansas State College, Manhattan, now has a new, well-equipped laboratory for technical and basic studies of the newer insecticides. This laboratory is equipped for technical, chemical and physiological tests. A new bio-assay procedure in which houseflies are exposed to materials containing insecticides, and the parts per million of the insecticide determined by the rate at which the flies die, has been perfected by Dr. Paul A. Dahm and his assistants. Much interest in the technical aspects of insecticides recently has been manifested among major students in entomology.

The Academy Committee on Educational Trends in Science Teaching, under the leadership of Dr. Homer Reed of Ft. Hays Kansas State College, is planning to make a study of present trends in the offerings of Kansas high schools in general science, general biology, botany, zoology, physics, and chemistry courses. A similar study was made by the Commitee several years ago, but it was felt enough changes have taken place in the meantime that a more recent study would be of value. Some of the problems which the Committee plans to study are:

1. The frequency of the offerings of each course.
2. Changes in the content of each course during the past decade.
3. Changes in the methods of teaching each course during the past decade.

4. Changes in the qualifications of science teachers during the past decade.

It is the hope of the Committee that some of the work can be undertaken by graduate students in education and science. Academy members who know of graduate students who might be interested or who have suggestions to make concerning the project in general are cordially invited to get in touch with Dr. Reed.

Another severe outbreak of cankerworms, particularly in the central part of Kansas, is reported this year by Dr. R. C. Smith of Kansas State College, Manhattan. Many towns employed airplane operators to spray their trees with DDT, and satisfactory results were obtained unless the spraying was done after most of the injury had been completed. The city of Manhattan obtained almost perfect control of cankerworms as a result of applying an oil solution of DDT by airplane on May 2. Not only did it destroy virtually all of the two species of cankerworms, but great numbers of a leaf-folding caterpillar; many May beetles and cutworms also were destroyed by the spraying.

Drs. T. F. Andrews and John Breukelman of Kansas State College, Emporia, are continuing their work this sumer for the State Fish and Game Commission on the limnology of Lake Feban, near Emporia. The lake has been recently drained to assist the biologists in their studies.

Under the direction of Prof. Hal J. Bender of the College of Emporia, members of the Flint Hills Geology Club made a trip to the Magnet Cave area, Arkansas, in May of this year. Mr. Bender was assisted by Academy members George Emrich, W. D. Jones, Clarence Gladfelter, all of Emporia, and A. C. Carpenter of Ottawa. The titanium mine and the barite quarry of the Cave area were visited as was the bauxite mine at Bauxite and the mineral museum at Joplin, Missouri. Collections of numerous minerals in the areas visited were made.

Dr. Reginald H. Painter, who has been on sabbatical leave at Ohio State University, will resume his work at Kansas State College, Manhattan, on July 1. Dr. Painer was awarded a post-doctoral fellowship, and has utilized his time during the year writing a book on insect resistance in plants.

Mr. H. J. Bender, assistant professor of geology at the College of Emporia the past two years, has resigned his position to accept a similar position at the University of Redlands, Redlands, Calif.

The many Academy friends of the delegation from Hays at the recent meeting at Manhattan, will be pleased to know that the accident which occurred to the car driven by Dr. F. W. Albertson, has resulted apparently in no permanent injury to any members of the party. The Albertson car, on its return trip from Manhattan, collided with another car near Fort Riley and the occupants, Profs. Albertson, Zinszer, Rankin, Dalton, and Mrs. Albertson were all more or less injured. At last report, all had recovered save Dr. Zinszer who was able to get around with the aid of crutches.

Field Manual of Plant Ecology by Dr. Frank C. Gates, professor of botany at Kansas State College,

Manhattan, and botanical editor of the *Transactions,* has been recently published by the McGraw-Hill Book Company of New York. The 137-page book has been in the process of development for the past thirty years in a course taught by Dr. Gates at the University of Michigan Biological Station and gives directions for exercises and experiments which enable the student to begin the study of plant ecology in the field. The list price of the manual is $3.00.

To a higher degree perhaps than any other agricultural industry, the citrus industry of the United States is dependent on science and technology. This fact fully warrants the effort necessary to produce a monumental three-volume treatise, *The Citrus Industry,* of which volume II was published in 1948 by the University of California Press at Berkeley and Los Angeles and retails at $10 a copy. The first volume, *History, Botany, and Breeding,* was published in 1943 and contains 1,050 pages. Volume II, *Production of the Crop,* contains 948 pages. The third volume, *Harvesting, Marketing, and Utilization of the Crop,* is now in preparation. Together, the three volumes will be one of the most comprehensive and authoritative discussions ever published of a single American agricultural industry.

Edited, like volume I, by Leon D. Batchelor and the late H. J. Webber, both of the Citrus Experiment Station at Riverside, volume II is the work of 16 authors, of whom 14 are, or have been, members of the faculty of the University of California and two are members of the staff of the United States Weather Bureau. The book's 18 chapters cover the whole range of subjects pertinent to the production of citrus fruits in the United States. While numerous comments are made regarding these subjects outside California, and even outside the United States, the book is devoted chiefly to citrus production in California.

Beginning with a fascinating chapter by Dr. Webber on nursery methods—rootstocks, budding, top working, etc.—and closing with two informative chapters on low temperatures in relation to citrus production, the book is a rich store of information about soil treatment, pest control, irrigation, and other essential production features of a great agricultural industry. The authors have performed veritable prodigies of labor in the conduct of research and in the analysis and summarization of the pertinent literature. They certainly have given us something interesting and important to think about while we ingest our matutinal citrus juice.—F. D. Farrell

The Kansas Ornithological Society was organized at meetings held at the University of Kansas on May 21 and 22. The Society begins with a charter membership of 110 and elected officers as follows: Dr. Ivan Boyd, Baker University, Baldwin, president; Dr. H. T. Gier, Kansas State College, Manhattan, vice-president; Rev. E. A. Delmon, Atchison, secretary; Mr. L. B. Carlson, Topeka, treasurer; and Dr. Charles Sibley, University of Kansas, editor.

Mr. Earl Nixon, State Geological Survey, Lawrence, has been granted a three months' leave by the Survey. Mr. Nixon left May 28 for the Yukon where he will do exploratory work for the United States Steel Corporation seeking deposits of iron, coal and limestone.

Dr. Elizabeth Conrad has been appointed instructor in chemistry at Kansas State College, Manhattan. Dr. Conrad began her work at Manhattan on April 4.

Mr. Charles Hess of McPherson College is making progress on his investigation of the antibiotic properties of Kansas plants for which he was awarded a grant this past year by the Research Awards Committee of the Academy. Mr. Hess has so far tested the extracts of some nine different plants for bacteriostatic activity and is continuing further studies in this field.

Professor William Mathews of the physics department, Kansas State College, Pittsburg, is the author of an article "A Review of Science in General Education" which appeared recently in *Social Science in General Education,* a volume edited by Earl J. McGrath, U.S. Commissioner of Education. Mimeograph copies of Professor Mathews' article are available by writing him at Pittsburg.

The fiftieth nation-wide testing program under the direction of Dr. H. E. Schrammel of Kansas State College, Emporia, was held on April 12. Nearly six hundred orders for over a quarter million copies of the test were received from 37 states. A summary of the results of tests is furnished the participating schools, thus enabling teachers to compare and to evaluate student work.

Advantage will be taken of the summer months for advanced study by a number of instructors in Kansas colleges. Professor William Johnson, *chemistry,* Tabor College, will continue his graduate work at Kansas State College, Manhattan; M. E. Brooks, *biology,* Kansas State College, Emporia, will go to the University of Colorado, Boulder; from Kansas State College, Hays, Harlan B. Johnson, *chemistry,* will go to Kansas State College, Manhattan; Wilmont Toalson, *mathematics,* will attend the University of Colorado and Walter Fleming, *mathematics,* will go to the University of Minnesota.

Dr. Edwina A. Cowan has joined the firm of Drs. Conwell, Street, and Kurth of Wichita as a consulting psychologist, working with the firm on a part-time basis.

Kansas will have a good representation at the University of Michigan Biological Station at Cheboygan, this sumer. Dr. F. C. Gates, Kansas State College, Manhattan, and Dr. H. B. Hungerford, University of Kansas, Lawrence, will serve, as they have for many years, on the teaching staff. Dr. D. J. Ameel, Kansas State College, plans to continue his investigations on the embryology of the trematodes at the Station, and Mr. Leo Petri, also of Kansas State, and Miss Dorothy Taft, University of Kansas, will be students during the summer session of the Station, June 20 to August 13.

"The Peacetime Uses of Atomic Energy" by Dr. Paul W. Gilles of the University of Kansas, was printed in May as a bulletin of The Bureau of Government Research, University of Kansas, Lawrence. The bulletin discusses atomic energy as a possible source of power production, as a source of power for transportation, and as an aid in scientific research, especially in investigations of plant and soil chemistry and of internal medicine. Copies of the bulletin may be secured by addressing the Bureau of Government Research, Lawrence.

Dr. Luther L. Lyon of the University of Wichita Foundation for Industrial Research, together with a number of students, has been working the past two years on the determination of surface areas of a number of commercially important powders. As a result of this investigation, two methods of measurement previously in use have had their range of usefulness considerably increased until it is now possible to measure the surface area of any material. Such diverse materials as zinc oxide, corn starch, carbon black, and red lead have been measured by both methods. Application of the methods to wheat flour have made it possible to correlate particle size and surface area with other properties of such materials.

Among the promotions recently announced at the University of Kansas, Lawrence, were included

To *professor*
- A. B. Leonard, *zoology*
- E. O. Stene, *political science*
- E. L. Treece, *bacteriology*
- Calvin VanderWerf, *chemistry*
- Herbert Wright, *psychology*

To *associate professor*
- W. J. Argersinger, *chemistry*
- Eldon Fields, *political science*
- Rufus Thompson, *botany*

To *assistant professor*
- Rollin Baker, *zoology*
- Henry Fitch, *zoology*
- Lee Myerson, *psychology*
- Frank Peabody, *zoology*

Summaries of reports on various aspects of animal husbandry made at Livestock Feeders' Day at Kansas State College, Manhattan, on May 7th are available for any person interested. The reports include research on beef cattle feeding and management, meat investigations, lamb and swine feeding and management, and studies in the development of the livestock industry in Kansas. Copies of the summarized report may be obtained by addressing the State Agricultural Experiment Station, Manhattan.

A letter from G. Perry Grimsley, geological engineer for the Baltimore and Ohio Railroad Company, now retired, will be of interest to older members of the Academy. Mr. Grimsley was secretary of the Academy from 1902 to 1905 and upon his removal from Kansas he was made an honorary member of the Academy. Mr. Grimsley writes in part: "I am pleased to note the progress of the Academy in the years since I left Kansas. I have been away from the state for over thirty years but I still call myself a Kansan. In the early days I knew every member of the Academy and all were my good friends, but I fear many of them have passed on. I wish for the Academy its continued success."

The Uses of Penicillin and Streptomycin by Charles Scott Keefer has recently been published by the University of Kansas Press, Lawrence. Dr. Keefer, professor of medicine at Boston University, reviews penicillin in medical and surgical practice, streptomycin in the treatment of infections, and concludes his 72 page book with a discussion of antibacterial agents from microbes. The book contains an index and lists for $2.00 a copy.

Publications of the State Geological Survey, University of Kansas, Lawrence, issued since our March number include:

Ground Water in Southwestern Kansas. John C. Frye and V. C. Fishel, 24 pages, 5 cents.

Scenic Kansas. (reprint) Ken-

neth K. Landes. 20 photographs, 14 pages, 5 cents.

Copies of the above publications may be obtained from the Survey for the mailing charge stated.

President Paul Murphy has announced his committees for the coming year's work of the Academy. We reprint the complete list below. Examine this list and if your name is found there you will know there is work to be done. If the chairman of your committee hasn't written you, write to him and ask him what you are expected to do. Committee chairman, too, should correspond immediately with the president and the secretary in planning the work of the year. President Murphy's list includes:

PROGRAM COMMITTEE
- A. M. Guhl, Chairman

MEMBERSHIP COMMITTEE
- A. M. Guhl, Chairman
- W. H. Schoewe, K.U.
- H. A. Zinszer, F.H.K.S.C.
- P. S. Albright, University of Wichita
- F. U. G. Agrelius, K.S.T.C., Emporia
- J. R. Wells, K.S.T.C., Pittsburg

AUDITING COMMITTEE
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- Roy Rankin, F.H.K.S.C.
- Andrew Riegel, F.H.K.S.C.

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- Wm. H. Matthews, K.S.T.C., Pittsburg
- R. E. Mohler, McPherson College

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- F. C. Gates, K.S.C.
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- John Breukelman, K.S.T.C.

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- Andrew Riegel, F.H.K.S.C.
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Harold Choguill, F.H.K.S.C.
W. S. Long, Kansas Wesleyan
Sister Waring, Marymount
Sister Horner, St. Marys College
Sister Payne, Mt. St. Scholastica
P. H. Pretz, St. Benedicts
L. V. Heisey, McPherson College
J. A. Glaze, K.S.T.C., Pittsburg
Ruth Thompson, Sterling
Helen Evers, Southwestern
D. C. Schaffner, C. of Emporia
F. U. G. Agrelius, K.S.T.C., Emporia
J. C. Frazier, K.S.C.
L. C. Woodruff, K.U.
Hazel E. Branch, Wichita U.
H. E. Crow, Friends U.
John Davis, Ottawa U.
D. D. Driver, Hesston
S. L. Loewen, Tabor

Junior Academy News

Items for this column are invited from all Junior Academy sponsors and members. For inclusion in any given issue they should be sent to the Junior Academy editor, Miss Edith Beach, 812 Illinois Street, Lawrence, Kansas, at least three weeks before our publication dates, namely the fifteenth of March, June, September and December.

The Kansas Academy of Science establishes with this issue the Junior Academy section of its *Transactions.* All Junior Academy members and sponsors are urged to contribute to this column for only by so doing can this service be made interesting and worthwhile. You all are cordially invited to send in reports of projects that members and sponsors have found of value and interest. All club notes, programs, reports, etc., should be sent to the Junior Academy editor, Miss Edith Beach, 812 Illinois Street, Lawrence, Kansas.

The Kansas Junior Academy of Science state meeting was held at Manhattan April 29, 1949. The following program was presented:

Wichita High School East: Polariscope, Dale Krasser; Magic, Max Armstrong; Tesla Coil, Richard Keys; Crystals, Paul De Busman; Luminal, John Wall.

Clay Center Kaolin Science Club: Transmitting Sound Over a Beam of Light, Kale Gentry; Stroboscope, Stanley Kappleman; The Spectroscope, Frank Swenson; Toxicology and Alkaloidal Analysis, John Barnes; Colloids, Wayne Nyberg.

Pittsburg High School: Talk on Cancer, Norma De Ridder; Display Work as a Help in Biology, Betty Pacconi and Peggy Jackson; Use of Filter in Photography, John Ward; Some Early Spring Flowers, Norma Jean Barbero assisted by Joan Trumbule; The History of Aeroplane Models, Harley Smith; Sulphuric Acid, Richard Comstock and Bill Toeller; Photography in Nature Study, Joan McClure assisted by Bunny Lindsay.

Labette County Community High School: Atomic Energy, Merwin Brillhart; A Radio on a Panel, Robert Sillcott.

Manhattan High School: Extraction and Isolation of Chlorophyll, Wasren Reynolds; The History of Tube Lighting, Rannells King and Ronald Showalter; The Chemistry of Photography, Richard Hodgson.

Lawrence Junior High School: Types of Codes and Cyphers Encountered in Police Work, John Feist; Field Trip System, Dorothy Pickel; Operation of a CO_2 Engine, Charles Fisher; Snakes, Talk and Demonstration, David Horr.

Independence High School: Neoprene—The Universal Synthetic, Bill Pittman; A Dry Cell Battery Charger, Allen Mason; A Capacitance Relay, Ralph Bretches; Automobile Turn Light Signal System, Jim Gillmore; Ram Jet and Rocket Propulsion, Bernard Schmitz; An Electronic Interval Timer, Gilbert Hammond.

At the business meeting, the following officers were elected: President, Richard Comstock, Pittsburg; Secretary, David Horr, Lawrence.

The judges awarded prizes to the following:

Best club program: Pittsburg, 1st; Wichita, 2nd; Manhattan, 3rd.

Best club exhibit: Pittsburg, 1st; Lawrence, 2nd; and Wichita, 3rd.

Individual exhibit: Robert Reiter, Lawrence, 1st; David Horr, Lawrence, 2nd; Danny Wiley, Lawrence, 3rd.

Talks: Merwin Brillhart, Altamont, 1st; Allen Mason, Independence, 2nd; Earl Herrick, Manhattan, 3rd.

Demonstrations: Pittsburg, 1st; Wichita, 2nd; Clay Center, 3rd.

The AAAS award for the best individual report went to Norma Jean Barbero, Pittsburg.

Norma Jean Barbero, Pittsburg, who received the AAAS award, assisted by Joan Trumbule, gave a very interesting report of their study of spring flowers, representing 58 different families. These 58 specimens were arranged in three rows of test tubes, mounted on a large flower basket, painted white, with cross bands of purple beneath the test tubes. On these bands were the common names and family names of the specimens, including early spring flowers and shrubs. A large white handle topped the basket and two large flower bouquets were placed on either side of the basket.

It was pointed out that all flowers in the lily family have their parts in threes: mustard flowers make the sign of a cross; and flowers of the composite family have many small flowers mounted on a common receptacle.

From time to time we will publish in this column short papers by Junior Academy members descriptive of their interests and projects. All members are invited to contribute such reports. The reports should be brief, to the point, and simply written. Be sure of your facts. For the first of these reports we present "Some Lower Vertebrates (Snakes)" by David Horr of Lawrence Junior High School. The report was given in greater detail at the Junior Academy meeting in Manhattan on April 29.

Some Lower Vertebrates

David Horr

During the seven years I have been collecting lower vertebrates I have often been asked, "How can you touch those nasty, slimy things?" The answer is simple. They are neither nasty nor slimy. In fact, I have found them to be very interesting animals. They are, however, the most misunderstood and unappreciated animals living today. They have been accused of all sorts of terrible things—such as, all being poisonous, stinging people with their tails and tongues, spitting poison at you, charming their prey so they cannot escape. These stories are all false.

On the other hand, snakes are very beneficial animals. Their diet consists of insects, small rodents, fish, frogs, lizards, and occasionally birds, birds' eggs, and sometimes other snakes.

Another question often asked is, "How can snakes swallow animals larger than themselves?" This is possible because of the way the jaw bones are hinged. In addition to this, each jaw can be moved forward or backward independently of the other.

Some snakes lay eggs while others give birth to living young. In America the greater number give birth to living young. Regardless of how the young are produced they are on their own from the

start. Of course many are destroyed by natural enemies and some are even eaten by their own mothers.

Snakes depend almost entirely on their sense of sight and smell. They have no ears and their sense of taste, if they have any, is poorly developed. They use their tongues in smelling things. During the months of activity snakes moult about once every six weeks. In doing this they shed the outermost layer of their skin which is called the cuticle. This shedding allows the snakes to grow. Being cold-blooded animals, snakes are active only on warm days.

Most snake collectors wear leather boots and carry a snake stick and a first aid kit. There are three kinds of snake sticks in common use. Harmless snakes can be caught with your bare hands. When a snake is collected, notes should be taken on the time and place taken, and the name of specimen.

If you do not keep your snakes alive you can kill them by drowning, by injecting formalin into the heart or with ether.

To prepare a permanent specimen you slit the belly in two or three places, coil the snake neatly in a glass container and cover it with 70% alcohol containing 10% formalin. Then after a couple of weeks the jar should be emptied and refilled with straight 70% alcohol, as continued contact with the formalin will destroy the color of the specimen.

The only kinds of poisonous snakes found in Kansas are the copperhead and the rattlesnake. They have poison only for killing their prey and they will not fight unless they are frightened or disturbed. If a person is bitten, first aid should be administered at once. The first aid consists of putting a tourniquet between the wound and the heart and making an X-like cut about one-fourth inch deep over the wound. If you have no sores in your mouth you can suck out the poison with your mouth. The tourniquet should be loosened for a minute every fifteen minutes and then tightened again. A doctor should be called at once. Stimulants, such as whiskey, should never be used because they speed up the flow of blood and carry the poison to the heart faster.

Greetings to Members of the Junior Academy of Science of Kansas.

MARGARET PARKER

JUNIOR ACADEMY CHAIRMAN
KANSAS STATE TEACHERS COLLEGE,
PITTSBURG

"The security and prosperity of the United States depends today, as never before, upon the rapid extension of scientific knowledge. So important, in fact, has this extension become to our country that it may reasonably be said to be a major factor in national survival," said Mr. John R. Steelman, Assistant to the President, in the opening sentences of his report of the President's Scientific Research Board.

Thus our economic growth and our military strength have become almost wholly dependent upon research in pure science. For the relation between science and military power we need only remember the atomic bomb. The expansion of our economy must come through the development of new industries, which are the result of research and invention.

Few of us realize the extent to which we have imported research in science from Europe to keep our industrial system going. The basic discovery of atomic fission is a European discovery. In a full page

picture section of *Life* several years ago there appeared the pictures of nineteen scientists connected with the atomic bomb; two were from the United States. Our contribution was our engineering ability, along with large financial resources and our talent for organization. While we were successful we must remember the basic research originated across the sea. Other European discoveries mentioned in the Steelman report include DDT, sulfa drugs and radar.

If we as a nation are to meet our needs in the advancement of scientific knowledge, we will have to make immediate and large scale efforts to encourage and train science talent among our young people.

Does science talent in Kansas need to go undiscovered and undeveloped? Through our science clubs and the Junior Academy we can interest and guide those who possess inherent talents that go to make successful scientists and at the same time give all pupils an understanding of science, of the importance of scientific research and of the dependence of our economy upon science.

Young people, even at the elementary level need to keep their hands and minds busy. Alert teachers encourage these youthful minds to find out "why." Our schools, too, need to give high administrative priority to programs designed to encourage and guide young people who show promise of developing into creative scientists.

Most colleges and universities of Kansas have prepared scientific exhibits and programs suitable for assembly and club programs. For many years the physical science department at the Kansas State Teachers College, Pittsburg, has had such a program which is still available for any science club or high school. There should be many valuable suggestions for science projects come from such exhibits and programs.

Many larger cities and universities are holding science fairs. Annual fairs are now held in St. Louis, Philadelphia, Washington, D. C., and one near us at the University of Oklahoma. At the University of Oklahoma exhibits are made in four sections of science—biology, chemistry, physics and geology. The prize individual exhibit at their fair this year was a model of a fault in the mountains near Lawton, Oklahoma. Two students from Ada, Oklahoma, exhibited a very unique lens grinding machine they had constructed. Among other exhibits were butterfly and insect collections, collections of leaves and flowers of Oklahoma, Tesla coils and a home-made chicken brooder and chicken house.

What can you as a member of the Junior Academy do to develop your science talent?

There are so many geological formations in Kansas that interesting collections of common rocks of a region would be worthwhile. This idea might be carried further into semi-micro chemical analysis of the materials of the rocks.

The field of plastics is very new. Some of you will be interested in manufacturing plastics and then working with them. Plastic lenses and prisms may be used for optical instruments. Simple molds for thermo-setting plastics may be made in school shops.

Senior Academy members, as well as your own science instructors, will be able to give you some suggestions for studying the conduction of electricity through vapors. By following out these suggestions you may study the spark

spectrum of many of our elements.

Fluorescence and phosphorescence of materials is worthy of study. Many ordinary flowers, including the iris, are fluorescent. Egg shells at a very low temperature fluoresce. Purple X bulbs emitting ultraviolet light for producing fluorescence are manufactured by the General Electric Company and are available for $1.25 each.

Have you seen a duck sink in water? A flock of geese landed on a pool containing oil and water. The oil caused their feathers to become wet and before they could be retrieved they drowned. Wetting agents are important and have a definite use in our daily life. A duck placed in water containing a wetting agent, such as aerosol, will sink. Wetting agents are found in detergents to aid in taking out the dirt.

Some of you will find that many interesting experiments can be performed with small transformer cores that can be taken apart. Coils suitable for various hookups such as ordinary step up or step down of voltage, or the operation of a Tungar rectifier, a radio power unit, an audio oscillator, a soldering transformer, a spot welder or a metal etcher.

Acoustics is a field where we seldom see a student work. Recently in an empty room of a new school building there was an interesting study carried out to show reflection of sound, reverberation time, and standing waves. Similar studies may be carried out in gymnasiums and school auditoriums.

Through the summer you may be reading and collecting material for new projects and by next spring at our meeting have some worthwhile reports to make.

Each one of you should feel free to contact Senior Academy members for help and suggestions for your projects. Suggestions for projects, too, may occur to you if you will examine each quarterly issue of the *Transactions* published by the senior members of the Academy. Your sponsor will be glad to lend you a copy for examination and study. Let us all strive to make this one of our most outstanding years, and try to interest students to carry on projects and bring their reports to our academy meeting next spring.

Message from the Senior Academy President

One of the major purposes of the Kansas Academy of Science down through the years has been to interpret the field of science to Kansas young people and stimulate them to become interested in it. It has worked toward this goal principally through the medium of the Junior Academy. Much time, thought, and patient effort on the part of many people has gone into the promotion of the Junior Academy program, and much has been accomplished by it. This year, for example, over one hundred high school students registered for the Junior Academy program at Manhattan, and displays and demonstrations were sponsored by a considerable number of science clubs.

We cannot afford to rest on our laurels. As successful as our efforts to date have been, the need for workers in the field of science is more pressing than ever. As Miss Parker has pointed out, we still rely too much on the scientists of other lands for basic research: and, of course, it is common knowledge that during the war years we failed

to make adequate provision for maintaining a flow of young people into our scientific laboratories. As a matter of fact, it will take years to make up the deficiency of scientists created by the shortsighted policies of the war years.

In recognition of its responsibilities in this area, then, the Senior Academy has selected as one of its major projects for the coming year, the revitalization of the Junior Academy. Again, let me emphasize that this statement is not to be interpreted as a reflection on the past work of the Junior Academy and its sponsors. Those who have carried on this work in the past are to be commended. There is always room for improvement and the Senior Academy feels that it is so important to undergird the work of the Senior Academy with a strong Junior Academy that it wishes to do all in its power to aid the junior organization.

We feel that a major step has been taken in the right direction in the selection of Miss Parker as chairman of the Junior Academy Committee. I believe that everyone will agree that her article in this issue is a forward-looking challenge to young Kansans. I know Miss Parker personally and know of her interest in this field. One of her first acts when she was apprised of her appointment was to visit the Science Fair at Norman, Oklahoma, sponsored by the Oklahoma High School Science Service, to get ideas that she might use in carrying on the work of the Junior Academy Committee during the coming year.

I want to express my gratitude, also, to Miss Edith Beach for her willingness to assume the editorship of the Junior Academy pages in the *Transactions*. This is a good omen too. Miss Beach has been identified with the work of the Junior Academy for many years and is one of the people responsible for the fact that we are starting this year with a strong, well-developed Junior Academy. A great deal of the success of any organization depends on facilities for communication among its units and members, and I am sure that no one will be left in the dark about what is going on with Miss Beach as editor of the Junior Academy section of the *Transactions*.

These two people, as competent as they are, cannot do the whole job, however. All they can do is to provide the framework for the Junior Academy program, and the ultimate success of this program will depend on the extent to which the members and clubs which make up the Junior Academy pitch in and do their share. As Miss Parker has pointed out, there are many opportunities for worthwhile projects in this area. Achievement will be limited only by the ingenuity and drive of science teachers and students in schools of Kansas. Just now, Science Fairs seem to offer one of the best types of projects around which school science activities can be organized, and it is to be hoped that a number of schools and colleges will see fit to sponsor such fairs during the coming year. Radio also offers a means for accomplishing certain desirable goals. Other types of projects will undoubtedly suggest themselves as the year progresses, and, of course, we will all be looking forward to the Junior Academy meeting in Wichita next spring which will offer an opportunity to bring the year's work to a rousing climax. From here, it looks as if this should be a Junior Academy program for the books.

ON TO WICHITA THEN! Some of the best brains in the whole country are to be found right here in Kansas, and if we all put them to work, the Kansas Junior Academy of Science can put itself on the map next year. And—don't forget that those of us in the Senior Academy stand ready to help in every way possible.

PAUL G. MURPHY, *President*
Kansas Academy of Science.

The Place of Research in Relation to Certain Phases of Stripland Reclamation in Kansas[1]

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New and important investigations have been undertaken recently by the U.S. Forest Service to decide many questions concerning the economic worth of striplands from a forestry standpoint. As these studies advance, much knowledge concerning practices, techniques and economics on the potentialities of forestry on stripped coal lands will be gained. Work of the Forest Experiment Station has been going on for several years in Ohio, Illinois, and Indiana, and its extension to include the Kansas-Missouri-Oklahoma area is indeed a fortunate development for the tri-state district.

It will not be possible for the Forest Service to answer all of the questions on stripland reclamation. Coal mining companies who own most of the disturbed land surface are concerned about other possibilities of reclamation as well as forest planting programs. Some of these possibilities have passed the demonstrational stage into the realm of practice. To encourage stripland reclamation for uses including that of forestry, it is needful that personnel of the U.S. Department of Agriculture, Kansas State Experiment Station, County, and Corporations become interested and lend effective aid.

Stripland reclamation divides itself into two physical divisions: denuded lands or spoil banks and water accumulations or ponds which result from disturbed natural drainage. Each of these divisions suggest interesting ecological studies of anthropeic habitats. These occur as dry, intermediate, and marshy habitats.

Succession, whether plant or animal, may undergo modifications which introduce pertinent economic aspects. For example, raw mine dumps are entirely free of plant growth. Within a comparatively short time some may become covered with weeds, grass, brambles, brushy shrubs, and quick-maturing trees. The list of native species found on spoil banks increase in length with the passing of time, but the rapidity of cover or stabilization depends largely upon the proximity of parent sources of seed furnishing vegetation. From an economic viewpoint it is desirable that plants growing on spoil banks be those of greatest value to the landowner. Artificial seeding and transplanting of desirable species and the elimination of unimportant ones are basic in speeding up succession.

Raw spoil banks can scarcely be called soil. Usually the resulting

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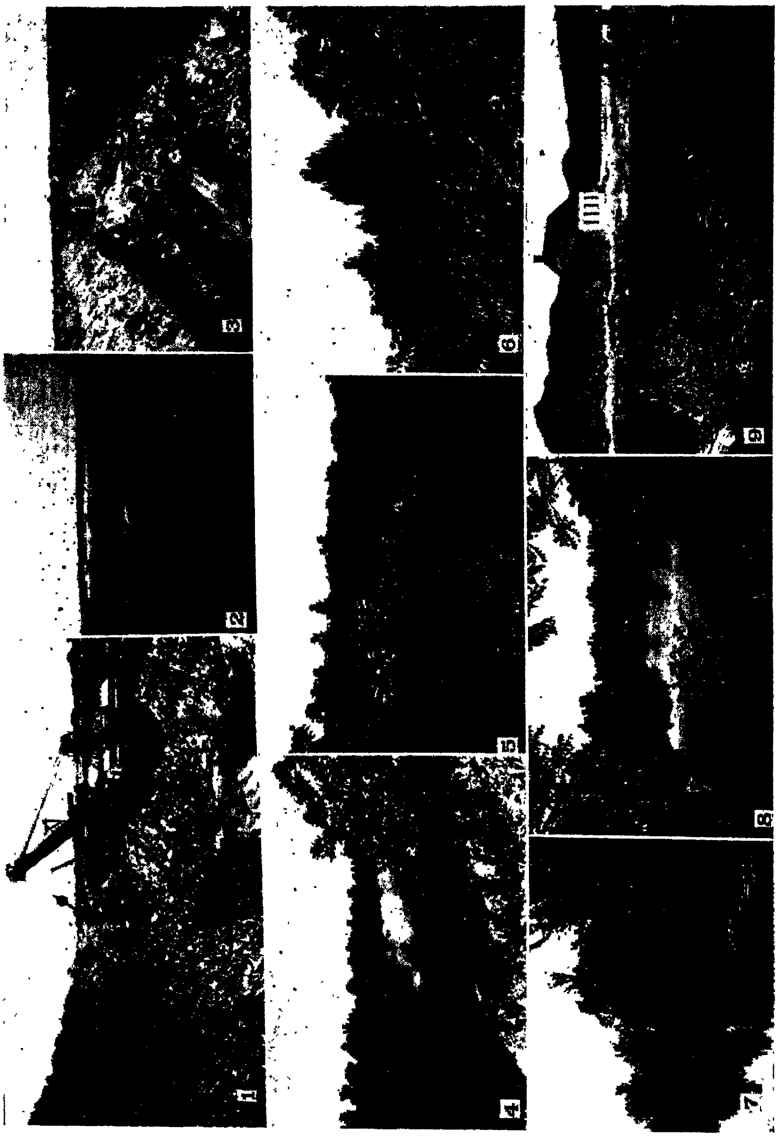
"soil" is a conglomerate of soil, clay, shale, and rock, loosely piled and without structure. The percentage of materials varies widely. Variations from clay to shale to rock often occur within short distances. The resulting "soil" is not a satisfactory seed bed and provides poor root anchorage. Often spoil banks are too rocky or contain materials which are toxic to plant and animal life. Throughout the reclamation program it is



necessary that soils experts study the numerous and complicated problems pertaining to stripland soils which are quite different from those formed by natural means.

Among present known uses for stripped coal lands are pastures, forest products, horticultural crops, recreational and wild-life developments, and bee culture. None of these interests has been fully studied. Each of these pursuits raises a multiplicity of questions which need to be answered correctly before the fullest state of development of stripland can be realized.

A number of pasture developments have been observed on mine dumps. In some instances native grasses covered most of the disturbed area and are being grazed with a fair degree of success. In other instances white sweetclover, *Melilotus alba* and Korean lespedeza, *Lespedeza stipulacea,* have been planted either by artificial or natural means. The growth of these has been sufficient to afford profitable gains. It is not yet known how successful other grasses and legumes might be on mine dumps. Very little is known about the quality of pasturage produced or the number of livestock per acre which may be safely pastured at various times of the year. Nothing is known about seeding methods, soil preparation or fertilization. Part-leveling of spoil banks is expensive and total leveling is almost prohibitive in cost. No one seems to know how much leveling, if any, is needed to make a good useable pasture for different kinds of livestock.

Information on the use of spoil banks for agronomic purposes is

Fig. 1. A 14-yard electric shovel in the shallow coal field of southeastern Kansas. Spoil bank at the left is partly formed by the diggings of a 9-yard dragline with a 200-foot boom. The dragline removes about ten feet of overburden and deposits it on top of shale piled up by the shovel. Reclamation is more easily accomplished when rock and shale are buried as shown in this photograph.

Fig. 2. A pit about forty feet deep, opened by a 33-yard electric shovel. On the next trip through, the shovel will fill the present pit and open a new one on the left of the one shown here.

Fig. 3. Raw mine dumps in Cherokee County, Kansas. Photograph taken a few weeks after coal had been stripped.

Fig. 4. A typical strip pit west of Pittsburg, Kansas. Pits vary in depth from a few feet to as much as forty feet. The water is usually fresh and is suitable for fish and muskrat culture.

Fig. 5. Black walnut trees dwarfed by fire and rabbit damage. Thrifty trees are shown in the distant background.

Fig. 6. Mixed planting of black walnut and ponderosa pine on the State Quail Farm near Pittsburg. Planting made in 1935 by C.C.C., photograph taken in 1946.

Fig. 7. A small strip pit on the Fleming N.Y.A. Project. Area along the bank had been planted to American elm and species of willow in 1941, photograph taken in 1948.

Fig. 8. A typical recreation area on the State Quail Farm near Pittsburg.

Fig. 9. Rural school house surrounded by mine dumps and pits, southwest of West Mineral, Cherokee County, Kansas.

almost totally lacking. No one has attempted to investigate the possibilities of tillage except on a very limited scale on leveled land. It appears that long weathering and judicious use of plant residues may precede successful farming on an intensive or diversified scale on stripland. "Soils", as they commonly exist on mine dumps, are mostly unweathered clays which are relatively rich in mineral reserves but are low in organic matter. Native soils of the strip-mine district are notably acid and require considerable lime for successful establishment of sweetclover. However, sweetclover and lespedeza grow very readily on spoil banks without adding lime. When established, these legumes spread rapidly on favorable sites and remain as cover indefinitely unless overgrazed by livestock.

Some experimental work has been done by the U. S. Forest Service in planting forest tree seedlings and by direct seeding of acorns and other nuts. For the most part these plantings were made on part-leveled land and can be termed successful. Plantings on nearly completely leveled sites are less thrifty. It is surmised that part of the difference in growth is due to soil compaction brought about by leveling with heavy mechanical equipment. It is not known which forest species might be planted throughout the stripped area and the degree of adaptability to certain soil reaction which might limit their use. The direction in which spoil banks are laid down causes differences in slope values. It is questionable, until tests are made, which species prefer northern and northeastern slopes which are cooler, and which species become established on the southern and western exposures which are often hot and dry. Certainly the difference in response to microclimatic conditions by forest species should be studied.

Wide spread forest plantings should not be made without a careful analysis of marketing possibilities. Some fast-growing species which produce quick cover may prove to be much less valuable to the landowner than slower-growing species. Posts, railroad ties, mine props, pulpwood, saw timber, furniture, baskets, boxes, crates, and fuel are some of the uses for which markets are within reach of the grower of good stands of forest trees in the strip-mine area.

Knowledge of the rapid disappearance of native black walnut in southeastern Kansas through commercial use has stimulated planting of this species on spoil banks. Stands of black walnut have been successfully established by direct seeding on certain spoil banks where seedling transplants have failed. Stands on poor sites are generally thin and unthrifty. Much could be learned concerning black walnut on stripland if a series of experiments were maintained on density of stand, value of mixed stands, pruning, tolerance to toxic soil conditions, the effect of

high and low water tables, resistance to disease, insects, rodents, fire, and other hazards.

Black locust has been used as a quick cover on mine spoil banks with gratifying results. It is doubtful if any post crops have been harvested from spoil banks in the district but in some plantings made in the late '30's are many trees which would yield two to four posts. It is not fully understood how much benefit may be expected from black locust as a nurse crop in mixed hardwood stands.

The production of fruit is almost a "natural" within the strip-mine area. Many local residents are first and second generation emigrants from Europe whose training and in-bred love for growing plants make them first-class fruit and vegetable growers. There is a good local market for fruit and vegetables. The trade area is large enough to support a considerable acreage of horticultural crops if such an industry is developed.

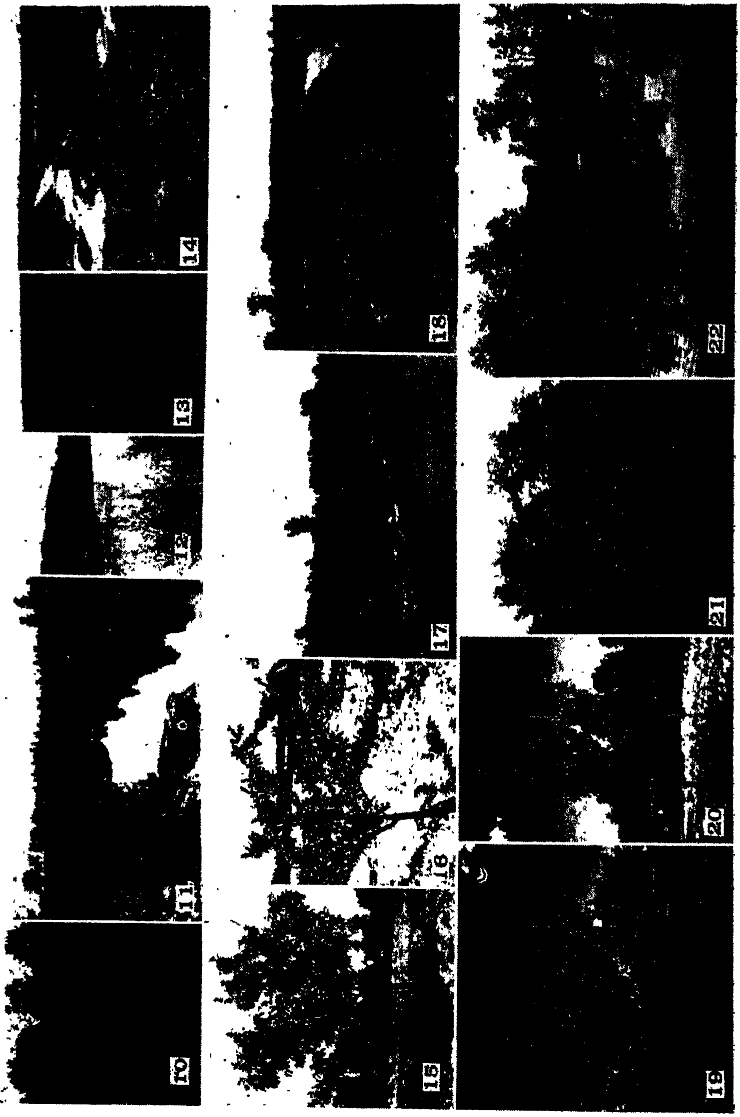
If it were not for its native clay-pan soils, southeastern Kansas might well be an important fruit growing district. The relatively mild climate is particularly favorable for peach production. Strip-mining activity is centered between the 40-and 50-inch rain belts, with an average of 190 days without a killing frost. The average date of the last killing frost in the spring is April 11th with a deviation of 25 per cent for killing frosts falling ten or more days later than the average. The average date of the first killing frost in the fall is October 21st. The normal annual minimum temperature is -7° with a deviation of 20 per cent for temperatures falling as much as 9° below the average minimum. There is less difficulty with alternate high and low temperatures in the spring which often kill fruit buds and blossoms elsewhere in Kansas. Several important peach-growing districts have less promising climatic features than those of southeastern Kansas.

Test plantings of carefully selected varieties of peaches were made on the Fleming National Youth Administration Project near Pittsburg in 1941. Several of the varieties under observation appear to be satisfactory and have produced good crops despite haphazard care. There is a need for study in discovering dependable sprays for the control of brown rot, scab, and peach leaf curl. Cultural problems are numerous. Site selection, soil management, and fertilization are important factors in production which should be investigated.

Apples, pears, plums, and cherries, while slower to develop, are relatively longer lived and represent a greater investment than that of peach production. A great amount of testing is needed before varieties of tree fruits can be recommended as suitable on a commercial scale.

Varieties of the American grape, *Vitis labrusca*, under reasonably

good management seem to be one of the most promising fruits for use on stripland. Sixteen commercially important varieties of grape were planted on the Fleming Project by NYA workers in 1940. All of these were thrifty and productive after their second year in the vineyard. Eight years later this planting was in good condition after having had less than average care. The grape is especially favored as a possible commercial fruit crop on stripland because of its dependability for good production and



the rapidity with which it can be brought into bearing.

Nut crops are well worth considering for use on stripland. A few observational specimens of Thomaas walnut and Chinese chestnut are doing very well on the Fleming Project after a slow start. With the relatively large amount of native black walnut seedlings available in established stands it appears that selections of superior stock could be top-worked on native trees for rapid, inexpensive production.

Limited development of specialized biological industries are suggested as a possible means of making profitable use of stripped areas. Ponds, or "pits" as they are locally termed, formed between spoil banks would make ideal water gardens for the propagation of aquatic plants, fish, and frogs. The Alabama Experiment Station has been experimenting with aquatic gardens and fish ponds for several years. Information recently released indicates that some ponds in Alabama are yielding as much as $100 per surface acre per year for fish, bait, aquatic plants, and frogs. The growing of aquatics for distribution to wildlife refuges and private ponds is a recognized industry in Wisconsin. Fur farming, fish and frog culture, culture of drug plants, biological laboratories, wild fowl sanctuaries,

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Figs. 10, 11, 12 Three types of volunteer cover which appear on spoil banks in the strip mine area.

10—Bluestems on weathered banks near Minden Mines, Missouri. Stripping completed about 1939. Photograph taken in 1946.

11—Cottonwood growing on rocky unleveled mine dumps south of Cherokee, Kansas. Area was stripped in 1943, photograph taken in 1948.

12—White sweetclover on weathered bank northeast of Cherokee, Kansas. Stripping completed about 1938. Photograph taken in 1948.

Fig. 13. Flat prairie land east of Minden Mines, Missouri, adjacent to No. 14. Predominant grass species are bluestems, switch, Indian, and side oats grama.

Fig. 14. An "island" of undisturbed prairie left in center of a large stripped area near Minden Mines, Missouri. Spoil banks are partly covered by volunteer grasses and legumes. Weathered five years. Photograph taken in 1948.

Fig. 15. Chinese chestnut (Castanea crenata) planted in 1941 on the Fleming N.Y.A. project. Height of tree when photographed June, 1948, eleven feet.

Fig. 16. One of Hansen's hybrid plums fruiting on the Fleming N.Y.A. project, southwest of Pittsburg, Kansas. Site is on stripped coal land partly leveled by C.C.C. and N.Y.A. personnel.

Fig. 17. Black locust on spoil bank west of Minden Mines, Missouri. Seedlings were planted about 1937 by Minden Mines high school classes in vocational agriculture. Photograph taken in 1946.

Fig. 18. Young grape planting on spoil banks which have been partly leveled. Plants were set in 1944 by Pittsburg and Midway Coal Mining Company southwest of West Mineral, Kansas. Photograph taken in 1946.

Fig. 19. Apricot trees planted on Fleming N.Y.A. project in 1941. Photograph taken in 1946. Note that the tree in the foreground is slightly higher than the stadia rod.

Fig. 20. A test row of pears adjoining the apricot planting shown in No. 19.

Fig. 21. Young black walnut trees with stems pruned to a height of eight feet. Trees were established by direct seeding by C.C.C. personnel in 1936. Photograph taken 1948.

Fig 22. Part of an old stripmine area east of Pittsburg, Kansas. Aquatic plants shown are sedges, bulrush, yellow water lily and willow. Pit waters are well stocked with fish and muskrats. Stripping was done in days of horse-drawn scrapers and small power shovels.

Photographs Courtesy of the Soil Conservation Service

hunting and fishing lodges, and rest camps are among the list of special enterprises which could be examined for income by those who enjoy pursuits of this type.

In view of the abundance of sweetclover and the long growing season, possibilities of commercial honey production are very favorable in southeastern Kansas. Literally thousands of stands could be supported by sweetclover alone—especially where livestock grazing on the clover spreads its blooming habit over most of the frost-free period. A report on the Chain-O-Lakes farm owned by the Pittsburg and Midway Coal Mining Company states that bees feeding on sweetclover produced 70 pounds of honey per hive, which was marketed at 50 cents per pound. Twenty-two hives averaged more than 35 dollars per hive. With careful supervision over the industry southeastern Kansas could develop an important income from honeybees.

The ultimate goal of reclamation and rehabilitation of stripped coal land requires coordination of recommendations and practices. These could then be incorporated into individual farm plans with emphasis placed upon a central farm enterprise or purpose. The Soil Conservation Service has used this method in its conservation program with a high degree of success. It appears that a farmer should be able to make a reasonably good living from stripland by properly handling limited acreages of forest plantings, orchards, berry crops, and pasture land. To supplement his income the farmer could expect profitable returns from poultry, bees, fish, and fur-bearing animals.

It is easy to point to examples of needed research but it is not easy to instigate experimentation. How could a reasonably complete research program for stripland be accomplished? How important is the matter of reclamation of stripped coal lands? Mining companies in at least twelve states are engaged in the active business of stripping shallow coal beds. Their combined operations have resulted in the conversion of more than 250,000 acres of land surface into spoil banks. Each of these states faces a reclamation problem whether or not they consider it to be important.

During the past forty years some thirty thousand acres have been stripped in the Kansas, Missouri, and Oklahoma area. It is estimated that between 100,000 and 150,000 acres will be stripped in the district before known sources of strippable coal are exhausted. Shallow coal beds of the nation, when entirely stripped, will represent something near 1,000,000 acres.

Kansas mined 4,573,000 tons of coal in 1943, the value of which was placed at $11,433,000. Part of this production came from shaft

mines. Stripping operations in Kansas netted $3,017,707 tons in 1944 and 2,904,521 tons in 1945.

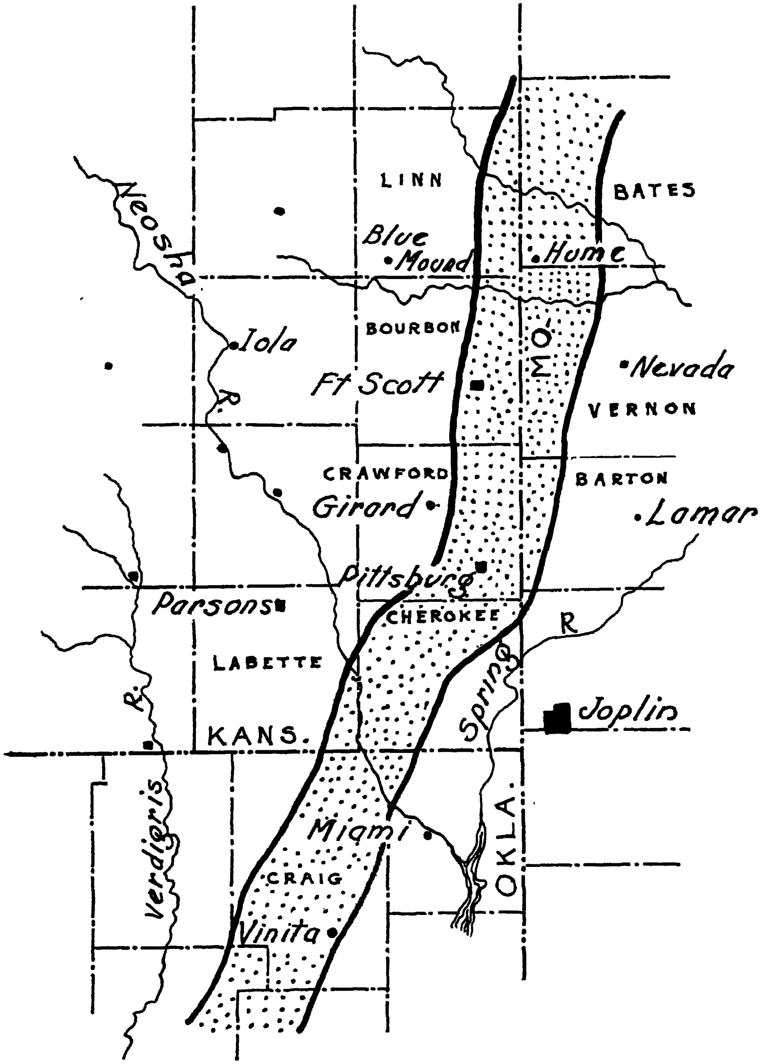

Fig. 23. Map of portions of Kansas, Missouri, and Oklahoma showing the tri-state strip coal district.

Obviously the state's strip-mining industry is large enough to carry a generous portion of costs of research studies needed on stripland which they own and which they created. An assessment of a few cents per ton would set up and equip a staff of technicians capable of studying most of

the angles of stripland use. However, it should not be necessary for coal companies to pay for all of the research needed on stripped coal lands. State and federal government assistance in the form of supplemental funds to support field technicians seems reasonable. Other industries within the state are drawing upon state and federal funds to carry on their researches. Why should the coal industry be left out in view of the increasing area of stripped coal lands in the district? Effective legislation to bring about some form of regulation in strip-mine reclamation appears to be necessary and advisable. Coal companies who are operating with good intent in regard to reclamation need not be disturbed by a well-designed law, but those who are doing nothing to advance reclamation and apparently do not intend to do anything could be brought into line by effective legislation. Kansas does not have a regulatory law such as several states have enacted to bring about reclamation. Some laws are admittedly faulty and do not bring about the best form of land recovery. Posting of bonds before digging operations start, and a release of the bonds following compliance with the reclamation law, is one method employed to accomplish reclamation in West Virginia. A well-formed operative plan of research with costs divided between mining interests and state and federal governments should go far in answering questions on the best uses of stripped coal lands. An active program of reclamation and rehabilitation on the areas disturbed by strip-mining in Kansas would be a good investment. It deserves the hearty concurrence of all persons concerned with the state's welfare and economy.

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Statistical Quality Control In College Analytical Laboratories

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The wide spread use of statistical methods of quality control in industrial chemical laboratories[1 3 4], led the author to undertake the use of similar methods in a study of the reliability of results obtained by students in college laboratories. Twenty students in a class in elementary quantitative analysis collaborated in the studies. Each student made two determinations of each type selected for the experiments, and reported the results of both determinations, thus making possible a study of the range between the two check results as well as a comparison of the work of different students. The students had had previous experience in some of the analyses selected, such as the titration of an acid with a base, but were unfamiliar with the other experiments, such as the double indicator titration and the Volhard method for chlorides.

The first experiment was a comparison of a solution of an acid with a solution of a base, using methyl orange as an indicator. All students used the same solutions and the same burettes. Each made two runs only, using approximately 40 ml. of sample, and reported the volume of base required to neutralize 1.00 ml. of acid. The correct result as determined by several runs made by experienced analysts, was found to be 1.00 ml. of acid equivalent to 0.881 ml. of base. Students reported results ranging from 0.860 to 0.899. The average of the 40 results reported was 0.8788. In Table I are recorded all of the results obtained by the collaborators.

Table I—Comparison of an Acid with a Base Using Methyl Orange Indicator

Collaborator No.	Ratio of Base to Acid X_1	X_2	X	R
1	0.879	0.880	0.8795	0.001
2	.879	.880	.8795	.001
3	.870	.899	.8845	.029
4	.882	.891	.8865	.009
5	.871	.876	.8735	.005
6	.877	.877	.8770	.000
7	.873	.875	.8740	.002
8	.872	.880	.8760	.008
9	.882	.883	.8825	.001
10	.860	.881	.8705	.021
11	.883	.890	.8865	.007
12	.876	.877	.8765	.001
13	.879	.880	.8795	.001
14	.879	.873	.8760	.006
15	.881	.885	.8830	.004
16	.878	.879	.8785	.001
17	.823	.867	.8450	.044
18	.885	.891	.8880	.066
19	.891	.891	.8910	.000
20	.883	.883	.8830	.000
		Av.	0.8788	0.0074

X_1 and X_2 are results of individual runs. X is the average of X_1 and X_2. R is the deviation between X_1 and X_2.

The control limits were calculated from the data as follows[1,4]:
For average of two results by each student:

$$0.881 \pm A_2 \bar{R} = 0.881 \pm (1.88)\ (0.0074)$$
$$= 0.881 \pm 0.0139$$
$$0.8949$$
$$0.8671$$

where 1 ml. of acid is equivalent to 0.881 ml. of base. $A_2 = 1.88$, a constant factor depending upon the number of samples (2 for each student). $\bar{R} = 0.0074$, the average deviation between two samples, as shown in Table I. For range of two runs by each student:

$$D_3R \text{ to } D_4R = 0.0 \text{ to } (3.27)\ (0.0045) = 0.0 \text{ to } 0.0147$$

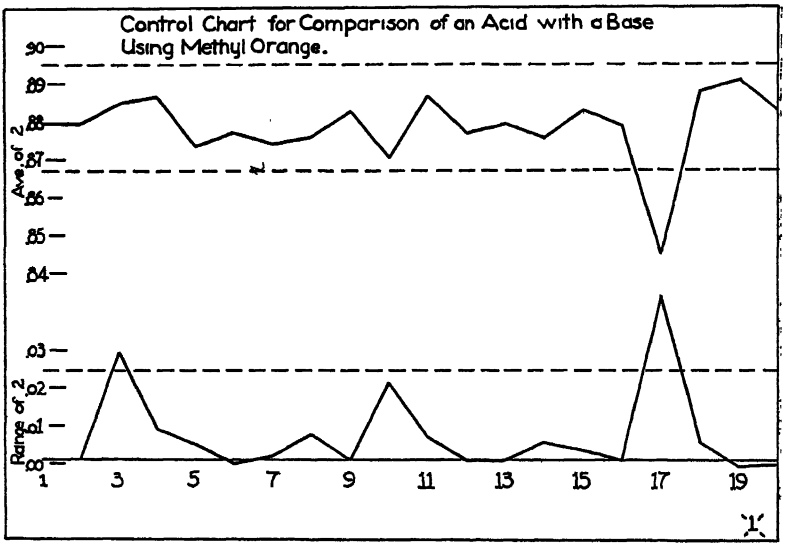

Figure 1

where $D_3 = 0.0$, a constant depending upon the number of samples, and $D_4 = 3.27$, a constant depending upon the number of samples, and $\bar{R} = 0.0045$, the average deviation between two samples.

In Fig. 1, the results have been plotted to show, by the upper curve, the average of the two determinations made by each student, and by the lower curve, the range between two determinations reported by each collaborator, thus showing how each student checks himself as well as his fellow students. In each case, the broken lines indicate the control limits as calculated above.

The figure shows that collaborator No. 17 is out of control both for

average results and for range of two, probably due to careless work. The variability between the results of different students as well as between check results is greater than those obtained by experienced analysts, as should be expected. It is also greater than is commonly allowed in college laboratories. The greatest range of two results as shown in Table I is 0.044 ml., an error of approximately 5%.

The acid-base comparison was repeated except that phenolphthalein was substituted for methyl orange. The results were tabulated and plotted as before, and the control limits calculated. To conserve space, the table will not be reproduced here, but the results are shown graphically in Figure 2. In this chart, as well as all others, the upper curve shows the average of two results, and the lower curve the range of two results. It appears that students get slightly more reproducible results with phenolphthalein than with methyl orange, but the agreement between students is less satisfactory for phenolphthalein than for methyl orange. In both cases the variability between students is greater than that of experienced analysts. Both range charts show student No. 17 badly out of control, due to careless work or inability to detect color changes.

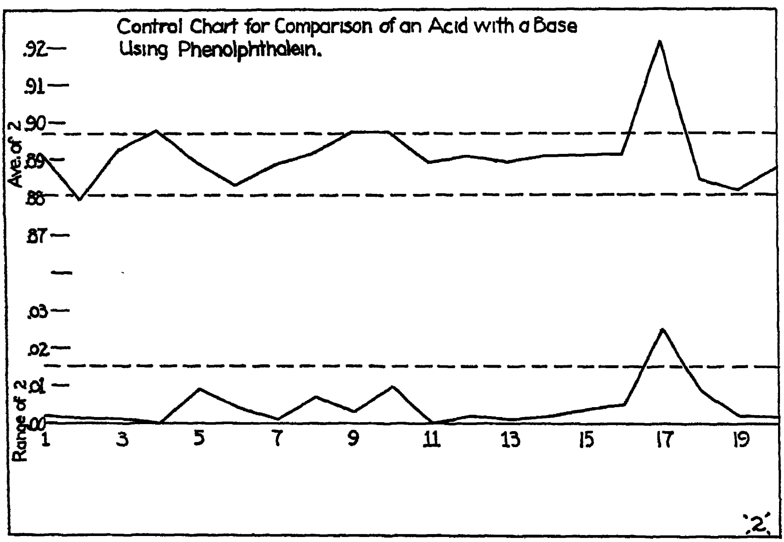

Figure 2

The class next titrated a sample of soda ash, all students using the same standard acid solution. The results of this experiment are shown in Figure 3. Again No. 17 is out of control and No. 12 nearly so. Excluding these two, the variability of duplicates is quite satisfactory,

although the variation among students is not as satisfactory. The correct result for this determination is 47.22%, and the control limit, calculated as shown for the acid base titration, is ±0.48. Therefore, to be in control, the average of two results for each student should be greater than 46.74 but less than 47.70. The chart shows students 2, 15, 16, and 19 to be

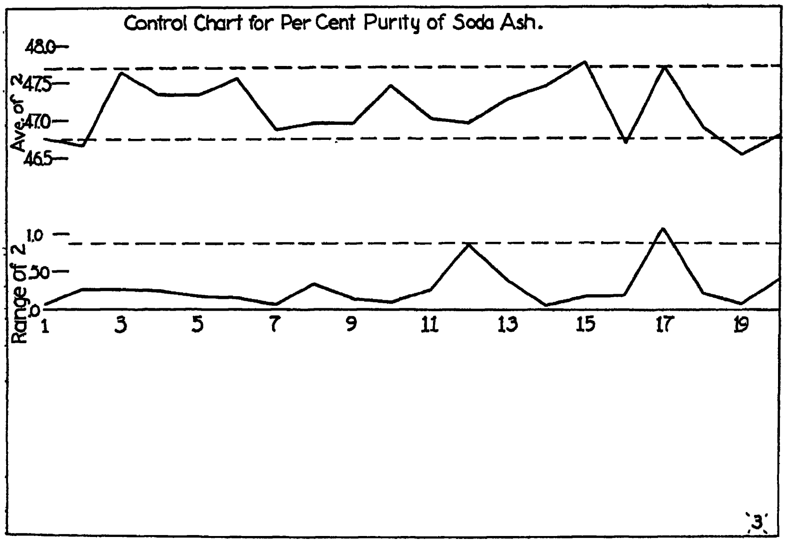

Figure 3

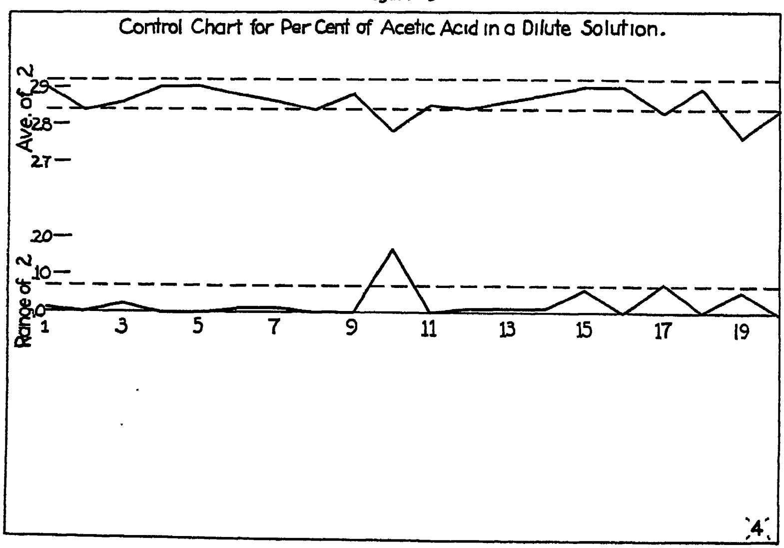

Figure 4

out of control, with several others near the limits.

Figure 4 shows the results obtained when a sample of acetic acid was titrated by each student, using the same standard base. The true value of this solution was 2.88% acetic acid, and the control limit was calculated to be ±0.04. All averages of two runs should therefore fall between 2.84% and 2.92%. The chart shows that two students are out of control for ranges, and also that more variation between students exists than corresponds to the average variability of duplicates. This variation may be caused by students not making true independent duplicate determinations, as there is always a tendency for beginners to compare their second end point with the first so that they will get good agreement.

The remaining experiments conducted were all determinations in which none of the students had had previous experience. The first of these was the titration of a mixture of Na_2CO_3 and $NaHCO_3$, using the double indicator method. The results are shown in Fig. 5, and, as might be expected from the fact that the determination is quite difficult, the results are rather poor. For Na_2CO_3, the control limits for range of duplicate determinations is calculated to be 0.0 to 3.06, and for the average of two, ± 1.76. The figure shows only one student to be out of control for the range of two results, but seven are out of control for the average of two results, and many others are nearly so. Fig. 6 shows the results obtained for $NaHCO_3$ in the same experiment, and as should be expected, they are similar to those obtained for Na_2CO_3.

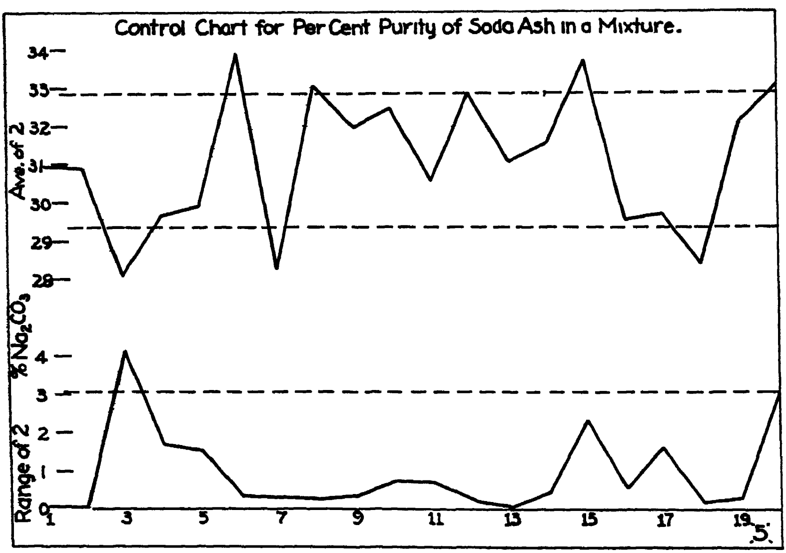

Figure 5

Fig. 7 shows the results obtained for the analysis of a soluble chloride by the Volhard method, also a new procedure for all of the group. The correct result here was 26.97% Cl, and according to the control limits

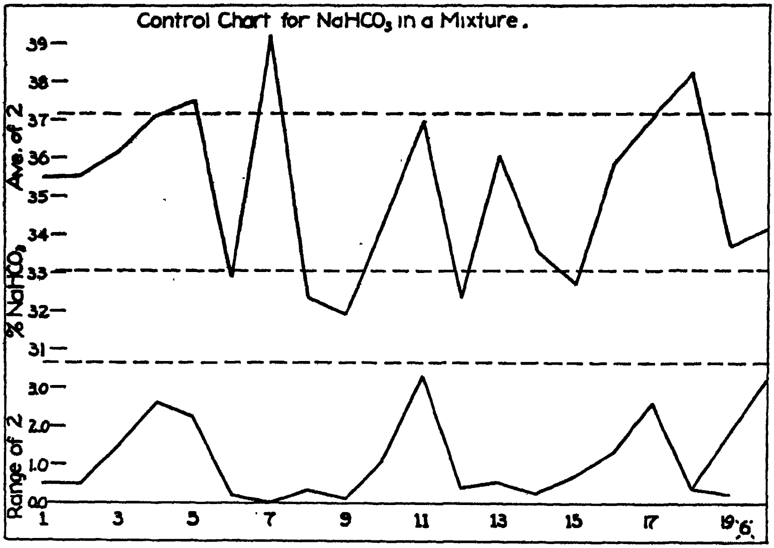

Figure 6

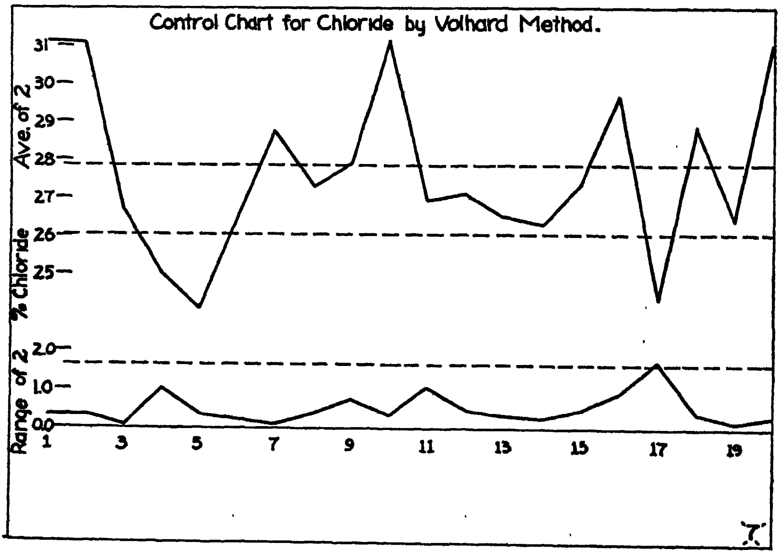

Figure 7

as calculated, all results should have fallen between 26.04 and 27.90%, with no greater range than 1.62%. The average range of duplicates is very great, and the agreement among students is very poor. This lack of agreement may be ascribed to the difficulty beginners have in detecting this particular end point.

The final experiment of this series was a volumetric determination of the iron content of a soluble iron salt. The results of this experiment are shown in Fig. 8, and as indicated by the chart, are more satisfactory than for the other experiments conducted. The range of two results is narrower (± 0.24) than in other experiments, as is the variability between the averages (± 0.14). In the range of two, no student is out of control. While seven are out of control for the average of two results, as shown by the upper curve, only one is badly out of control.

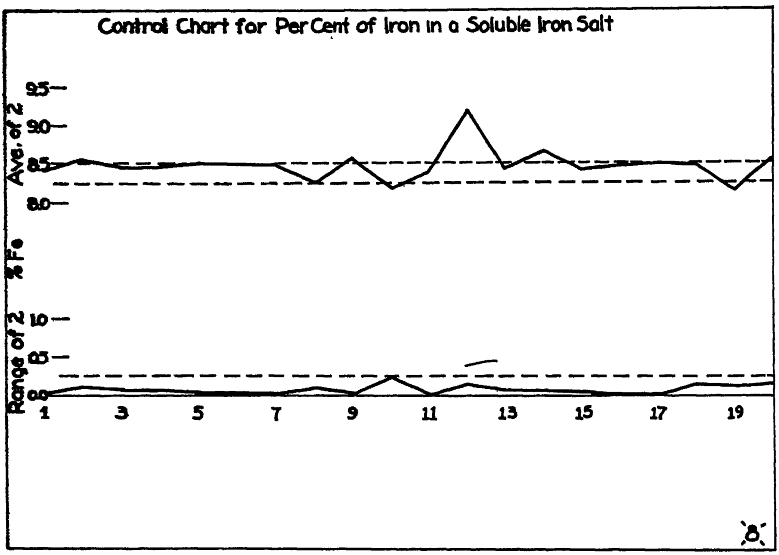

Figure 8

The results of the experiments indicate that beginning students, at least this particular group, are, in general, neither able to obtain closely duplicating results in volumetric methods of analysis nor to obtain close agreement with the results obtained by other students.

The author wishes to express his appreciation to the members of the class assisting in these experiments, and especially to Dr. Grant W. Wernimont of the Eastman Kodak Company, who calculated the control limits, plotted the results, and commented on them.

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Crustacea In Eastern Kansas

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Abstract

Twenty-nine species of Crustacea, exclusive of the crayfishes, are reported from temporary and permanent bodies of water within a 2½ mile radius of Lawrence, Douglas County, in eastern Kansas, where the topography is characterized by low, rocky hills, dissected by small temporary or permanent streams, well-drained slopes, and broad, poorly-drained floodplains. Trees such as oaks, hickorys, black walnut, elms, locust, cottonwood and others cover the hills while the slopes and floodplains generally support a cover of mixed grasses and herbs. The unevenly distributed annual rainfall varies between 35 and 45 inches, the greater part of which occurs in the spring and fall. Summers are frequently hot and dry.

Small pools in roadside ditches, along railroad fills, in drainage canals in floodplains and in pastures and woodlands are of frequent occurrence; these pools are richly supplied with vegetation which makes excellent culture media for small crustacean animals.

The following species, listed by orders, were found living in eastern Kansas; those names marked with an asterisk are new records for the state. Anostraca: *Streptocephalus texanus*, **Streptocephalus sealii*, *Thamnocephalus platyurus*, **Eubranchipus serratus*; Conchostraca: **Caenestheriella belfragei*; Cladocera: **Daphnia pulex*, **Daphnia longispina*, **Scapholeberis mucronata*, **Simocephalus vetulus*, **Simocephalus serrulatus*, **Ceriodaphina reticulata*, **Moina rectirostris*, **Bosmina longirostris*, **Chydorus sphaericus*, **Kurzia latissima*, **Leydigia quadrangularis*, **Pleuroxus denticulatus*; Podocopa (subclass Ostracoda): **Cypridopsis vidua*, **Physocpria pustulosa*; Eucopepoda (subclass Copepoda): *Diaptomus clavipes*, **Cyclops bicuspidatus thomasi*, **Cyclops vernalis*, **Eucyclops agilis*, **Atthey-ella illinoisensis*, **Microcyclops varicans*, **Macrocyclops albidus*; Isopoda: **Mancasellus ? sp.*, *Caecidotea tridentata*, **Armadillidium vulgare*; Amphipoda: **Hyalella knickerbockeri*.

Introduction

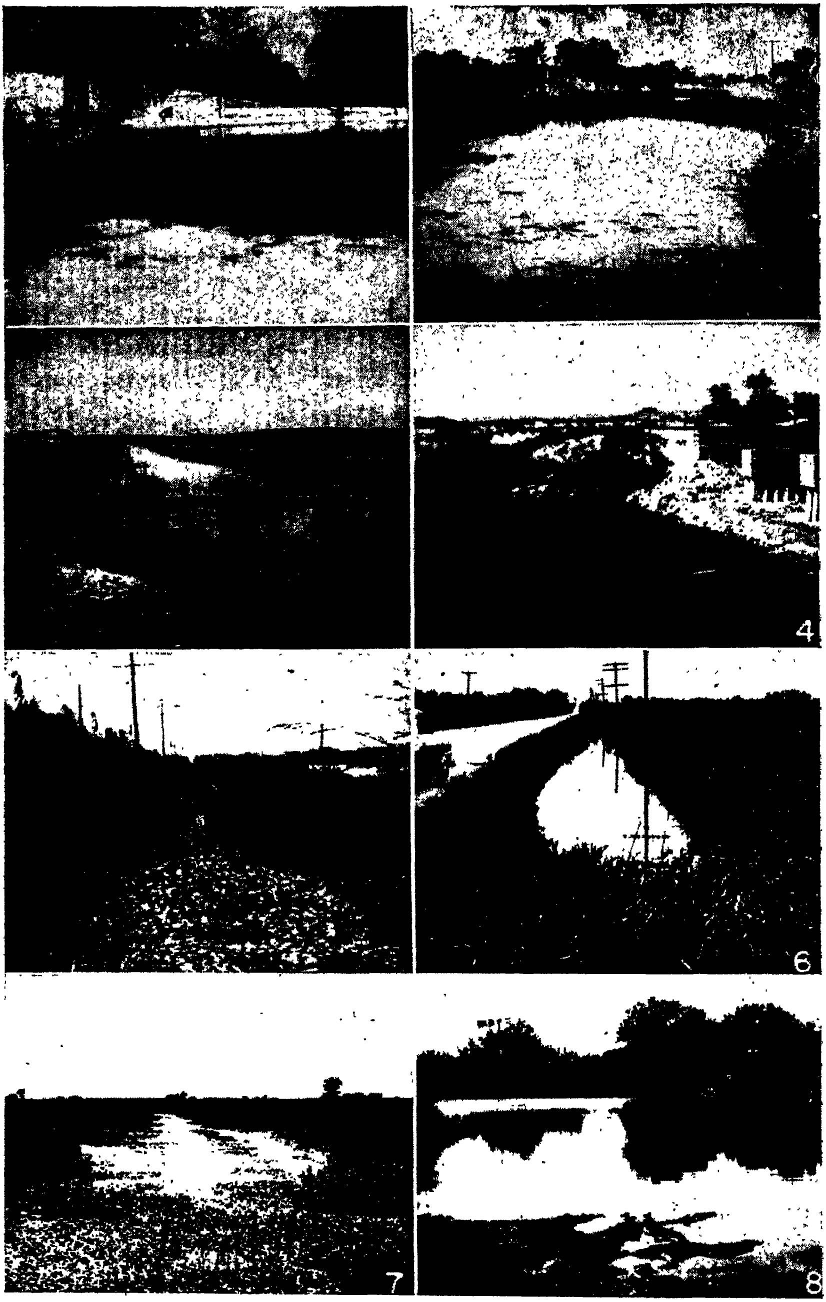
The twenty-nine kinds of Crustacea, exclusive of the crayfishes, here reported from eastern Kansas are from an area where the topography is characterized by low, rocky hills dissected by small temporary or permanent streams, well-drained slopes, and broad, poorly-drained floodplains. Oaks,

hickorys, maples, black walnut, elms, locust, cottonwood and other trees cover many of the hills, while the slopes and floodplains generally support a cover of mixed grasses and herbs. The annual rainfall varies between 35 inches and 45 inches, but precipitation is not evenly distributed throughout the year. The greater part of the total annual precipitation occurs in the spring and fall; the summers are frequently hot and dry.

Under these conditions, small pools in roadside ditches, along railroad fills, in drainage canals in floodplains, and in pastures or woodlands, are of frequent occurrence, although many are ephemeral, and may disappear during the greater part of the year. Since vegetation grows abundantly in these pools during relatively dry periods, the plant material provides an ideal culture medium for bacteria, protozoa, algae, and other planktonic organisms when the pools fill with water in periods of rainfall (plate I).

We are indebted to the following specialists for their kindness in verifying identifications of Crustacea found in eastern Kansas: Dr. John L. Brooks, Dr. Ralph W. Dexter, Mr. Melville Hatch, Dr. C. Clayton Hoff, Dr. Leslie Hubricht, Dr. J. G. Mackin, Dr. Willard G. Van Name and Dr. Harry C. Yeatman.

The earliest reports of microcrustacea in Kansas date as far back as the early 80's of the last century. At that time Packard (1883) published, as a part of Hayden's twelfth report of the United States geographic and geological survey of the territories, a monograph of the phyllopods of North America. Packard (1883: 295) states, "The Phyllopod Crustacea are especially characteristic of the western plains of our Territories, where the most striking and typical forms abound, one entire family (Apodidae) not occurring east of the western edge of the Mississippi Valley, while the most bizarre member of the entire group, the *Thamnocephalus,* lives in pools on the plains of Kansas". Packard obtained specimens of the following phyllopods from Dr. L. Watson of Ellis, Kansas: "*Lynceus brevifrons, L. mucronatus, Leptestheria compleximanus, Eulimnadia texanus, Apus aequalis, A. lucasanus, A. obtusus, Streptocephalus texanus* and *Thamnocephalus platyurus. Cyzicus mexicana, Eulimnadia texanus* and *Branchinecta lindahli*" were obtained from Professor Joshua Lindahl, Fort Wallace, Kansas. Hungerford (1922: 175-181) reported a new species of *Caecidotea* in eastern Kansas. Underwood (1886: 325) sensing the need for correlation of the scattered literature on the subject of the freshwater Crustacea of America, made an index of the described species of Crustacea of America, north of Mexico. Kansas was credited with eleven species of phyllopods, all of which had been reported by Packard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(1883) as having been received from Dr. L. Watson and Professor Joshua Lindahl.

For the most part, materials used in this study were collected from temporary and permanent bodies of water within a radius of two and one-half miles from Lawrence, Douglas County, in eastern Kansas. Within the period of February 1947 to May 1948, some thirty bodies of water, mostly temporary in nature, were studied. During the vernal and autumnal seasons weekly to semi-weekly visits were made to these pools and Crustacea taken from them.

Tools used in making collections and recording data were an ordinary dip net, a pond-life dip net of silk bolting cloth and plankton towing net of the same material, a Birge cone net, minnow seine, water dipper, two ounce vials, collecting jars and two and one-half gallon galvanized bucket, hand magnifying glass, centrigrade thermometer, camera, notebook and 5" by 8" cards. The dip nets and towing net were used for collecting the smaller forms and the minnow seine for collecting large forms such as *Thamnocephalus*. A two ounce vial was attached to the plankton towing net and when filled with organisms after several sweeps of the net through the water, was removed and capped with a screw top. The collecting jars were one or two quart sizes and were used for transporting collected specimens from the field to the laboratory.

Specimens brought into the laboratory were examined, recorded and

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PLATE I

Fig. 1. Potter's lake on University of Kansas campus 6 feet deep; open water surrounded by ice and snow, January, 1948; Daphnia pulex, Simocephalus vetulus, S. serrulatus, Scapholeberis mucronata, Bosmina longirostris, Chydorus sphaericus, Cyclops vernalis, Hyalella knickerbockeri common inhabitants.

Fig. 2. A railroad fill ditch 2½ miles SE of Lawrence, Kansas; 2 feet deep, May, 1948 Eubranchipus serratus, Daphnia pulex, Cyclops vernalis, C. bicuspidatus thomasi, Eucyclops agilis, Mancasellus ? sp. common inhabitants.

Fig. 3. A drainage ditch 2¼ miles NE of Lawrence, Kansas; 6 feet deep May, 1948; Streptocephalus texanus, S. sealii, Thamnocephalus platyurus, Eubranchipus serratus, Caenestheriella belfragei, Daphnia pulex, Diaptomus clavipes common inhabitants.

Fig. 4. A railroad fill ditch 2 miles north of Lawrence, Kansas; 4 feet deep; May, 1948; Daphnia pulex, Scapholeberis mucronata, Cyclops vernalis, Eucyclops agilis common inhabitants.

Fig. 5. Roadside ditch 2½ miles SE of Lawrence, Kansas, dry from June, 1947 to September, 1947, same as fig. 6.

Fig. 6. Roadside ditch 2½ miles SE of Lawrence, Kansas, 30 inches deep, May, 1948; Streptocephatus sealii, Caenestheriella belfragei, Eubranchitus serratus, Daphnia pulex, Ceriodaphnia reticulata, Cyclops vernalis, C. bicuspidatus thomasi, Eucyclops agilis, Diaptomus clavipes, Cyridopsis vidua, Physocypria pustulosa, Mancasellus ? sp common inhabitants.

Fig. 7. An oxbow lake 2¼ miles NE Lawrence, Kansas; 12 inches deep, May, 1948; Daphnia pulex, Ceriodaphnia reticulata, Scapholeberis mucronata, Cyclops vernalis, Simocephalus serrulatus common inhabitants.

Fig. 8. A pasture pool 1½ miles NW of the University of Kansas campus; 4 feet deep, October, 1947; Daphnia pulex, Simocephalus vetulus, Cyclops vernalis, Eucyclops agilis common inhabitants.

cultures were established until such time as specimens could be preserved in alcohol or mounted. Specimens were killed and fixed in 70 to 95 per cent alcohol in equal parts of water and preserved in 95 per cent alcohol. During the late fall and winter of 1947-48 pure cultures of cladocerans, copepods and ostracods were maintained in the laboratory for observation. Samples of water from which the specimens were secured were brought into the laboratory and the hydrogen ion concentration was determined with the aid of a Coleman potentiometer.

Photographs were taken of the various localities from which collections were made and date of collection, temperature of water, pH of water, character of the pool and its bottom, type of pool, and condition of water in it (whether clear, turbid, low or high, drying-up or flooded) were noted on the back of 5" by 8" cards to which the pictures were attached.

Small animals, and parts of taxonomic importance, from larger animals were stained in acid fuchsin and mounted in polyvinyl alcohol.

The life cycle of some members of the order Anostraca is little known because of the sporadic nature of their occurrence in temporary pools. Effort was made to correct this deficiency by taking eggs deposited by gravid females in laboratory aquaria, together with dead bodies of gravid females, and placing this material in a permanent pond on the University of Kansas campus. Also soil and water from the pools where Anostraca had been found were placed in laboratory aquaria and seeded with eggs. To date no Anostraca have appeared in laboratory aquaria nor in the campus pool. However, this result is not unexpected since records indicate that these animals may appear in a pond one year and fail to reappear for several years there after.

Check List of Microcrustacea In Eastern Kansas

Superclass: Crustacea Pennant
  Class: Eucrustacea Kingsley
    Subclass: Branchiopoda Lamarck
      Order: Anostraca Sars
        Family: Streptocephalidae Daday
          Streptocephalus texanus Packard
          Streptocephalus sealii Ryder
        Family: Chirocephalidae Prevost
          Thamnocephalus platyurus Packard
          Eurbranchipus serratus Forbes
      Order: Conchostraca Sars
        Family: Caenestheriidae Daday
          Caenestheriella belfragei (Packard)
      Order: Cladocera Latreille
    Suborder: Calyptomera Sars
        Family: Daphnidae Straus
          Daphnia pulex (deGeer)
          Daphnia longispina (O. F. Müller)
          Scapholeberis mucronata (O. F. Müller)
          Simocephalus vetulus (O. F. Müller)
          Simocephalus serrulatus (Koch)

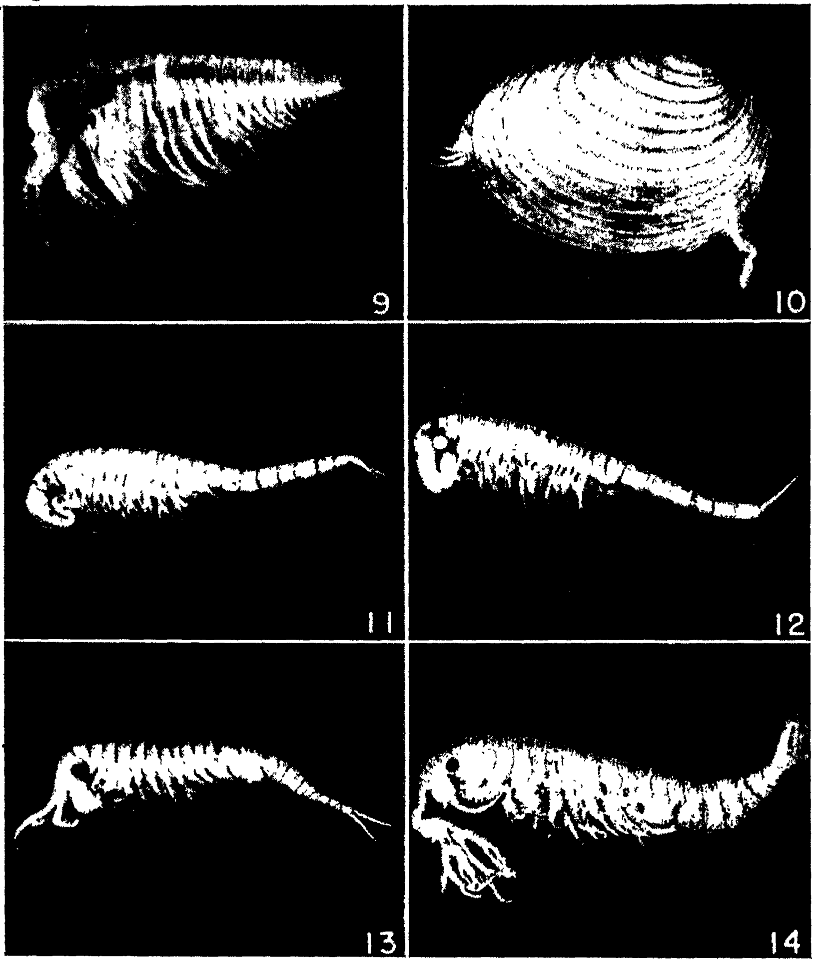


PLATE II

Fig. 9. Caenestheriella belfragei, adult ♂. x 6, shell removed, collected in drainage ditch 2¼ miles NE Lawrence, Kansas, October, 1947.

Fig. 10. Caenestheriella belfragei, adult ♂, x 6, enclosed in bivalve shell, collected in drainage ditch, 2¼ miles NE Lawrence, Kansas, October, 1947.

Fig. 11. Streptocephalus texanus, adult ♂ x 2, taken from drainage ditch 2¼ miles NE Lawrence, Kansas, October, 1947.

Fig. 12. Streptocephalus sealii, adult ♂ x 2, taken from drainage ditch 2¼ miles NE Lawrence, Kansas, October, 1947.

Fig. 13. Eubranchipus serratus, adult ♂ x 2¼, taken from drainage ditch 2¼ miles NE Lawrence, Kansas, March, 1948.

Fig. 14. Thamnocephalus platyurus, adult ♂ x 1¼, taken from drainage ditch 2¼ miles NE Lawrence, Kansas, October, 1947.

Magnifications are approximate

Ceriodaphnia reticulata (Jurine)
Moina rectirostris (O. F. Müller)
Family: Bosminidae Sars
Bosmina longirostris (O. F. Müller)
Family: Chydoridae Stebbing
Chydorus sphaericus (O. E. Müller)
Pleuroxus denticulatus Birge
Leydigia quadrangularis (Leydig)
Kurzia latissima (Kurz)
Subclass: Ostracoda Latreille
Order: Podocopa Sars
Family: Cypridae Sars
Cypridopsis vidua (O. F. Müller)
Physocypria pustulosa (Sharpe)
Subclass: Copepoda Latreille
Order: Eucopepoda Claus
Suborder: Calanoida Dana
Family: Diaptomidae Westwood
Diaptomus clavipes Schacht
Suborder: Cyclopoida Burmeister
Family: Cyclopidae O. F. Müller
Cyclops bicuspidatus thomasi Forbes
Cyclops vernalis Fischer
Eucyclops agilis (Koch)
**Microcyclops varicans* (G. O. Sars)
**Macrocyclops albidus* (Jurine)

Suborder: Harpacticoida Sars
Family: Canthocamptidae Westwood
Attheyella illinoisensia (Forbes)
Subclass: Malacostraca Latreille
Subclass: Malacostraca Latreille
Series: Eumalacostraca Brobben
Division: Pericarida Calman
Order: Isopoda Latreille
Suborder: Asellota Latreille
Family: Asellidae Sars
Mancasellus ? sp
Suborder: Oniscoidea Budde-Lund
Family: Armadillidiidae Budde-Lund
Armadillidium vulgare (Latreille)
Order: Amphipoda Latreille
Suborder: Gammaridea Dana
Family: Taliteridae Latreille
Hyalella knickerbockeri (Bate)

Annotated List of Species

Streptocephalus texanus Packard

Plate II, Fig. 11

Streptocephalus texanus Packard, Amer. Journ. Sci., ser. 3, 2: 111. August 21, 1871.

Recognition characters: Short laminate frontal appendage present, with slight fissure at distal end suggesting lobosity; eyes stalked; median, single ocellus present on anterodorsal border of head; first antenna filiform,

*Collected by Mr. Arthur L. Duell, May 1, 1948.

arising from dorsolateral angle of head immediately anterior to stalked eye, approximately 3 mm. in length; second antenna or clasper in male large, tortuous and three-segmented; basal segment cylindrical with lateral antenniform appendage arising at junction with second segment which is long and recurved; third segment enlarged and convoluted at junction with second segment, bifurcate, forming a scissors; shorter inner blade or branch of scissors with two unequal teeth on proximal anterior margin; proximal tooth approximately one-third as broad as distal tooth, and varying in shape from bluntly rounded to slightly pointed; distal tooth large and shaped like a plow-share; immediately distal to point of large tooth inner blade constricts, turns downward, enlarges again, terminating acutely; anterior to terminal apex of blade enlarged distal portion bears a lateral protuberance; outer blade or branch having thick base from which two processes issue: shorter, outermost digitiform; longer, innermost long, slender and curved, resembling blade of a scythe; second antenna of female flat and plate-like with short, pointed tip at apex; cercopods of both sexes uniformly setose along entire margins and colored brilliant red; penal organ long and retractile; egg sac long and conical, extending from attachment on first abdominal segment to about seventh abdominal segment, usually light blue to deep blue or rust in color. Creaser (1930b: 9) has proposed the common name, "The Smooth-tailed Fairy Shrimp", for this species.

Local occurrence and ecology: Collections of *S. texanus* were taken from a freshly dug drainage ditch approximately two and one-quarter miles northeast of Lawrence, Kansas, at intervals from October 9 to November 12, 1947. The drainage ditch in which these Crustacea lived lies in an old river bottom area which is flooded by spring and fall rains. The ditch, when completely filled, is approximately six feet deep and 25 feet wide and extends about one-half mile across a field which is under cultivation (fig. 3). The ditch has a soft clay bottom and is devoid of bottom growing vegetation. There was no growth around the borders of the ditch at the time collections were made since the area was being prepared for cultivation. Because of the recent excavation of the ditch and the lack of vegetation growing on the bottom, the water was very turbid. During the collection period the temperature of the water ranged from 34 degrees C. in October to 8 degrees C. on November 9 and 12. The hydrogen ion concentration of the water remained around pH 7.9 for the entire collection period. Packard (1883: 347) noted that he had received immature examples of *S. texanus* from Dr. L. Watson who had collected them from a "prairie pond" in Ellis, Kansas, in the vernal season of 1877 and later during the same season in Wallace. Kansas. No

examples of this species have been collected in the vernal season in eastern Kansas.

Authors have listed the habitats of the species as "prairie ponds", "cattle holes", buffalo wallows", and "tanks" or "pot holes". Jewell (1927: 295) reports *S. texanus* to have hatched from mud taken from a "buffalo wallow" in the sand dune area of Stafford County, central Kansas. Creaser (1930b: 8, 9) reports this species from Santana, south-western Kansas. Little is known about the life history of the Streptocephalidae. However, they are known to appear suddenly in temporary bodies of water and are capable of reaching maturity within 14 days or less.

According to Creaser (1930b: 5, 7) *texanus* has been reported from the neighboring states of Colorado, Oklahoma, Texas and farther west in Utah. Creaser (1930b: 8, 9) also states that the range of the species is more or less limited to south-western United States.

Streptocephalus sealii Ryder
Plate II, Fig. 12.

Streptocephalus sealii Ryder, Proc. Acad. Nat. Sci. Philadelphia, pp. 200-202, 1879.

Recognition characters: Laminate frontal appendage longer than in *S. texanus*, distal end entire with no suggestion of lobosity; eyes stalked; median, single ocellus present on anterodorsal border of head; first antenna filiform, approximately 3 mm. in length, arising from dorsolateral angle of head immediately anterior to stalked eye; second antenna or clasper in male large and not so tortuous as in *S. texanus,* three-segmented; basal segment long and cylindrical with long antenniform appendage arising from outer proximal border where basal segment joins second segment, which is moderately recurved, but shorter than basal segment; third segment greatly swollen at junction with second segment, bifurcate, forming a scissors; shorter inner blade or branch of scissors bearing two teeth, about equal in length, on proximal anterior margin; proximal tooth broadly conical, distal tooth about half as broad at base as proximal tooth; distal to second tooth, blade is slightly enlarged, hyaline, curved downward and terminates in a sharp point; outer blade or branch of scissors possessing a hollowed basal portion into which the two teeth of inner segment fit; outer blade also bears a short anterolateral protuberance, a posterolateral digitiform process, and a long, slender, slightly curved distal process which terminates acutely; second antenna of female ellipsoidal, longer than wide, pointed at apex; frontal appendage absent in female; cercopods of male stout, bowed, and fringed with long setae on proximal one-half of margins, distal one-half of margins bearing

sharp spines on inner and dorsal margins; cercopods of female uniformly setose along margins; cercopods of both sexes colored brilliant red; penal organ long and retractile; ovisac long and conical, reaching slightly beyond base of seventh abdominal segment, deep blue or pale green in color. Creaser (1930b: 9) has proposed the common name, "The Spiny-tailed Fairy Shrimp", for *S. sealii.*

Local occurrence and ecology: *S. sealii* has not been previously reported for Kansas, but the following collections of it have been made in eastern Kansas: October 9, and 10, 1947, four fully formed adults, two males and two females, were taken from a roadside ditch two and one-half miles southeast of Lawrence, Kansas, (fig. 6). October 30 and November 5, 1947, many fully formed adults of both sexes were collected from a drainage ditch two and one-quarter miles northeast of Lawrence, Kansas. The roadside ditch from which *S. sealii* was first collected in eastern Kansas was dry from June 7, to September 12, 1947 (fig. 5). Heavy rains on September 12 and 21 partly filled the ditch which was seined September 29 and 30 for crayfish, but no individuals of *S. sealii* were taken. On October 3, the ditch was worked rather thoroughly with a dip net without finding the species. On October 30, and November 5, 1947 fifty specimens of *S. sealii* were collected together with numerous specimens of *S. texanus* from the drainage ditch northeast of Lawrence. Several hundred specimens of *texanus* were taken from this ditch on several occasions before *sealii* suddenly appeared. Individuals of *sealii* collected from the ditch were larger than individuals of *texanus,* but were not so numerous. The sudden appearance of adult male and female *S. sealii* in pools in eastern Kansas on the above mentioned dates attests to the sporadic nature of the appearance of this fairy shrimp. Also, the sudden appearance of adults in ponds two to three weeks after vernal and autumnal rains seems to be characteristic of the species according to other authors. Because of the sporadic occurrence of this species little is known of its ecology or life history.

The habitat of *S. sealii* is generally reported by authors to be similar to that of *S. texanus.* Creaser (1930b: 8) states, "It is noteworthy that at the present time *S. sealii* and *S. texanus* have not been found together in the same ponds, although the ranges of the two species overlap. It is possible that some ecological or chemical factor of the environment is responsible for this segregation".

General distribution: Widely distributed in America; Creaser (1930b: 8) reports occurrences of the species as far north as Alberta, Canada, south to Mississippi and Alabama, west to Arizona and east to New Jersey. Reports have been made from neighboring states of Colorado (Dodds,

1915: 97-98). Oklahoma (Mackin, 1938: 45) and Texas (Resta, 1921: 96-98) Creaser (1930b: 5, 6) indicates that Packard's *Streptocephalus floridanus*, collected from St. John's River Florida; Dodd's *Streptocephalus coloradensis* collected at Fort Collins, Colorado; and Pesta's *Streptocephalus americanus*, collected from Dallas, Texas, are in reality synonyms of *S. sealii.*

March 30, 1948, Mr. Jerry A. Palmer brought into the laboratory examples of *S. sealii* measuring 42 to 45 mm. in length. These large individuals were collected in a pasture basin near Joaquin, Shelby County, Texas, March 28, 1948. According to Palmer, water in this basin is low, only a few inches in depth, at some seasons of the year, but the basin is never dry.

Thamnocephalus platyurus Packard

Plate II, Fig. 14.

Thamnocephalus platyurus Packard, Bull. U. S. Geol. and Geogr. Survey Territories, iii, 1: 175. April 9, 1877.

Recognition characters: Frontal appendage of male well developed, cylindrical, arising from anterior margin of head, greatly branched and thickly spinose on secondary branches; first antenna of both sexes slender, of moderate length; second antenna or clasper of male composed of two segments; basal segment short and thick with short spine on medial lateral border and an elongate hyaline process on inner border; second segment or clasping organ long, curved, simple, subconical, saber-like and chitinous; second antenna of female extremely long, flat and oar-like, extending over one-half length of body; penal organ long and retractile; ovisac long, conical and blue-green in color; oviducts colored robin's egg blue; cercopods of both sexes confluent.

Local occurrence and ecology: The first specimen of *T. platyurus*, a male, was collected from a recently excavated drainage ditch approximately two and one-quarter miles northeast of Lawrence, Kansas, October 27, 1947. This specimen measured 45 mm. in length. On October 29, 1947, the ditch was seined with a minnow seine and 11 additional specimens taken, four of which were females. The males measured from 45 to 47 mm., while the females were without exception 50 mm. long. The females are very strikingly colored; the tail is scarlet, ovisacs light green, oviducts robin's egg blue, swimming feet very pale green and the oar-like second antennae and remainder of body white. *Streptocephalus texanus* had been taken from this ditch on several previous occasions before the first collection of *T. platyurus* was made. Packard (1883: 354-355) gives an interesting account of the first collections of this species by Dr.

L. Watson at Ellis, Kansas, 1874. It is worthy of note that *T. platyurus* was originally found in a pool with *Streptocephalus texanus*. Packard (1883: 335) suggests that the habitat of *T. platyurus* is different from that of most other fairy shrimps in that it is not found in "Buffalo wallows" or upland pools. It is impossible now to reject or confirm this suggestion, since the species has been collected only twice in eastern Kansas. The life history of the species is little known. Individuals reaching maturity live for only a short time—possibly only a few days. The full cycle has not been observed in nature and the animals have not been cultured in the laboratory.

General distribution: The range of *T. platyurus* is apparently confined to central and southwestern United States and Mexico. Creaser (1935: 376) lists *platyurus* from Texas, Oklahoma, Kansas, Colorado, Arizona, U. S. A., and San Luis Potosi in Mexico.

Eubranchipus serratus Forbes

Plate II, Fig. 13

Eubranchipus serratus Forbes, Bull. Illinois State Lab. Nat. Hist. 1: 13. October 16, 1876.

Recognition characters: Frontal appendage of male arising from base of second antenna or clasper, laminate and asymmetrical, forming a broad sigmoid curve; proximal half of outer margin of appendage equipped with long spinose processes, distal half of outer margin possessing short, knob-like processes; inner border of appendage equipped with short, spinose processes of nearly uniform size; first antenna short and filiform, arising from anterolateral border of head, immediately in front of stalked eyes. Second antenna or clasper of male biarticulate; basal segment stout and elongate, second segment of moderate length, bowed, broader at proximal union with basal segment than at distal end, outer lateral surface hollowed; seen in profile, distal end of segment resembling a small slipper, inner proximal border armed with blunt, irregular process half as long as segment; second antenna of female irregularly ovoid, apex pointed; cercopods of both sexes uniformly setose along margins, colored red or amber; penal organ retractile, bearing spine on terminal end; ovisac irregularly rounded, colored rust or blue-green; swimming appendages of male and female variable in color, some pale blue, others rust colored or colorless.

Local occurrence and ecology: *E. serratus* has not previously been reported for Kansas, but occurs in eastern Kansas under a wide variety of field conditions. Depth, temperature, hydrogen ion concentration and turbidity of water seem to exercise little effect on these animals. Examples

of the species have been taken from pasture pools containing only a few inches of water; from ditches along roadsides and railroad fills containing from one to four feet of water; and from a drainage ditch where the water was approximately six feet deep. *E. serratus* has been taken from water ranging in temperature from 4 degrees C. to 23 degrees C. However, it has been observed that individuals swimming about in the warmer waters tend to congregate near the shady areas of a pool. *E. serratus* occurs in pools in eastern Kansas as early as February 15 and as late as May 12. Adults have been taken from pools covered with sheets of floating ice resulting from late winter and early spring thaws. On February 16, 1948, in a flooded field adjoining a deep drainage ditch two and one-quarter miles northeast of Lawrence, Kansas, thousands of dead bodies of fully mature male and female *E. serratus* were found lying in furrows in the earth about 12 inches deep under water on which ice floated. Apparently large numbers of *E. serratus* hatched in the furrows in January or early February and were unable to reach the surface where they could get sufficient quantities of oxygen because of the depth of the ice that covered the field from January 1, 1948 until February 12, 1948. Consequently, they died where they hatched and reached maturity. The bodies seemed to be well preserved but when handled broke up easily.

E. serratus may occur in water ranging in pH from 6.93 to 7.6. It thrives best in clear pools with weedy bottoms but is able to live in turbid water. Generally speaking, fairy shrimps thrive best in clear pools containing considerable vegetation.

There is considerable size variation in the species. Apparently local conditions are important factors in the size variation of *E. serratus* in pools in eastern Kansas. In some pools specimens collected in the spring of 1947 were larger than individuals taken from the same pools in the spring of 1948 and conversely, specimens taken from other pools in 1947 were substantially smaller than individuals taken from the same pools in 1948. Fully formed adults measuring a maximum of 20 mm in length have been taken from pools, whereas in other pools the length ranged from 10 to 35 mm.

Hay and Hay (1889: 91-95) concluded that eggs of *Eubranchipus* must be dried before hatching will take place. Creaser (1931: 267-268) suggests that drying may be necessary in some cases but not in all. Avery (1939:356) reports hatching *E. vernalis* eggs which were kept moist, while eggs permitted to dry failed to hatch. Dexter and Ferguson (1943: 211) observed that *E. vernalis* eggs which were kept at room temperature for several months and then placed in pond water failed to hatch.

General distribution: *E. serratus* has been reported from Oklahoma

(Mackin, 1938: 46); Illinois, Nebraska, Missouri (Creaser, 1935: 374); Ohio (Dexter and Ferguson, 1943: 210-222).

Caenestheriella belfragei (Packard)

Plate II, Figs. 9, 10.

Estheria belfragei Packard, Amer. Journ. Sci. ser. 3, 2: 112. August, 1871.

Caenestheriella belfragei, Daday, Ann. Sci. Nat. Zool. Paris, ser. 9. 20: 108-116. 1915.

Recognition characters: Dorsal and posterior margins of valves, seen from the side, forming a distinct angle; seen from above or below, broadly fusiform; greatest width near anterior end across umbones; valves with 23 to 26 growth lines edged with fine setae; surface of valves punctate; dorsal border of last 18 trunk segments, exclusive of telson, armed with hairs and spines increasing in size posteriorly; 19 to 25 teeth of unequal size on dorsal margin of telson; superior ramus of second antenna composed of 15 to 16 segments; inferior ramus 16 to 17 segments; third pair of feet on male and first pair of feet on female with distinct endopodital palp; apical border of second pair of feet of male armed with long, thin setae on side near base of apical claw; ninth and tenth pairs of feet of female equipped with distinct endopodital palps.

Local occurrence and ecology: *C. belfragei* has not been previously reported for Kansas, but examples of it were taken from a recently excavated drainage ditch two and one-quarter miles northeast of Lawrence, Kansas, October 29, 1947 and in a roadside ditch two and one-half miles southeast of Lawrence, Kansas, October 10, 1947, February 20, March 17 and 20, 1948. *C. belfragei* is a bottom dweller for the most part, occasionally swimming rapidly up to the surface of the water and just as rapidly sinking to the bottom. Specimens observed in the laboratory attacked and devoured smaller crustaceans such as *Cyclops, Diaptomus, Daphnia* and *cypridopsis*. Excreta from the digestive tract suggests that diatoms and other micro-plankton also form a part of the diet. Temperature and pH of water seem to have little effect upon the presence of *C. belfragei* in pools in eastern Kansas. Examples have been taken from water ranging in temperature from 5 to 35 degrees C., and from pH 6.8 to pH 7.9. Fewer specimens were collected in the colder, slightly acid vernal waters than in the warmer, alkaline autumnal waters.

General distribution: *C. belfragei* was first collected by G. W. Belfrage in the month of April, at Waco, Texas, and was reported by Packard (1871: 112-113). Mackin (1938: 47) reports the species for Oklahoma. A. Byron Leonard and Austin B. Williams collected examples of the species from roadside ditches in McPherson County, Kansas, and

from a pasture pool in Marion County, Kansas, in April, 1947. The geographical range of the species is unknown.

KEY TO GENERA AND SPECIES OF DAPHNIDAE IN EASTERN KANSAS

1. Rostrum present 2
   Rostrum wanting 9
2. No cervical sinus; carapace transparent 3
   Cervical sinus present; carapace opaque 5
3. Valves reticulated, oval to ellipsoidal, dorsoposterior margin terminating in long spine .... Genus *Daphnia* 4
4. Post-abdominal claw with pecten .... *Daphnia pulex*
   Post-abdominal claw without pecten .... *Daphnia longispina*
5. Posterior and ventral margins of carpace straight, the latter terminating in short spine .... Genus *Scapholeberis* 6
   Posterior and ventral margins not straight 7
6. Head and ventral margin of carapace dark brown to black .... *Scapholeberis mucronata*
7. Dorsoposterior margin of carapace terminating in bluntly rounded spine .... Genus *Simocephalus* 8
8. Vertex rounded, ocellus elongated .... *Simocephalus vetulus*
   Vertex pointed, armed with spines; ocellus rhomboidal .... *Simocephalus serrulatus*
9. Head small and depressed; antennules short; valves reticulated; post-abdominal claw pectinate .... *Ceriodaphnia reticulata*
   Head large and not greatly depressed; antennules long; valves smooth, ephippium reticulated around edges .... *Moina rectirostris*

Daphnia pulex (de Geer)

Plate III, Fig. 15.

Daphnia pulex de Geer, memoires pour servir a' l' Histoires des Insectes 7:950, 1778.

Recognition characters: Body heavy and transparent, armed with long posterior spine; antennules small and hidden, except for setae, which may extend beyond tip of rostrum; post-abdomen large, anus terminal; 12 or fewer anal spines; post-abdominal claw with pecten.

Local occurrence and ecology: Common in eastern Kansas, especially in spring and fall; apparently absent from open water in summer and in winter, although a laboratory culture carried on reproduction throughout the year. *D. pulex* is probably the most common and abundant crustacean in pools, ponds, streams and ditches in eastern Kansas. Shortly after the first spring and fall rains this animal may be collected in large numbers from almost any puddle or larger body of water. Although *D. pulex* has not been taken from pools in summer and winter, it is able to survive in water ranging in temperature from 5 to 27 degrees C., and in pH from 6.9 to 7.4. The foliaceous feet of *pulex* are in constant motion straining micro-organisms and debris from the water. Some of this plankton is engested and some rejected.

General distribution: Very commonly and widely distributed in America and Europe (Blake, 1935: 384); Birge (1918: 695) also indicates

a wide distribution for this species; Hoff (1943: 84) states that *pulex* is not common in Reelfoot Lake, Tennessee, but admits that his collections might have been made during a period of seasonal population decline.

Daphnia longispina (O. F. Müller)

Plate III, Fig. 16.

Daphnia longispina, Müller, Entomostraca, seu Insecta Testacea in aquis Daniae et Norvegiae reperta, p. 199. Lipsiae. 1785.

Recognition characters: Body heavy and transparent, armed with a long posterior spine; antennules small and hidden; head large and variable in shape from bluntly rounded to elongate, frequently terminating in a point; post-abdomen large, anus terminal; 9 to 14 anal spines; post-abdominal claw without pecten.

Local occurrence and ecology: *D. longispina* has not been reported previously for Kansas, but it occurs in the open water of large artificial lakes in eastern Kansas. The first examples of *D. longispina* taken in eastern Kansas were collected from Lone Star Lake, approximately 12 miles southwest of Lawrence, Kansas. Lone Star lake is as much as 45 feet deep and covers an area of 195 acres. Little is known about the ecology of *longispina* in Lone Star lake since only two collections of it have been made. However, a Birge cone net dragged behind a rowboat for from 150 to 500 yards collected large numbers of *D. longispina,* suggesting that during the month of April at least the species is very abundant in the lake. Contents of the intestines of dead individuals showed a predominance of diatoms and Protozoa.

General distribution: Found in open water of lakes in all regions of the United States and Europe (Birge, 1918: 696, 697).

Scapholeberis mucronata (O. F. Müller)

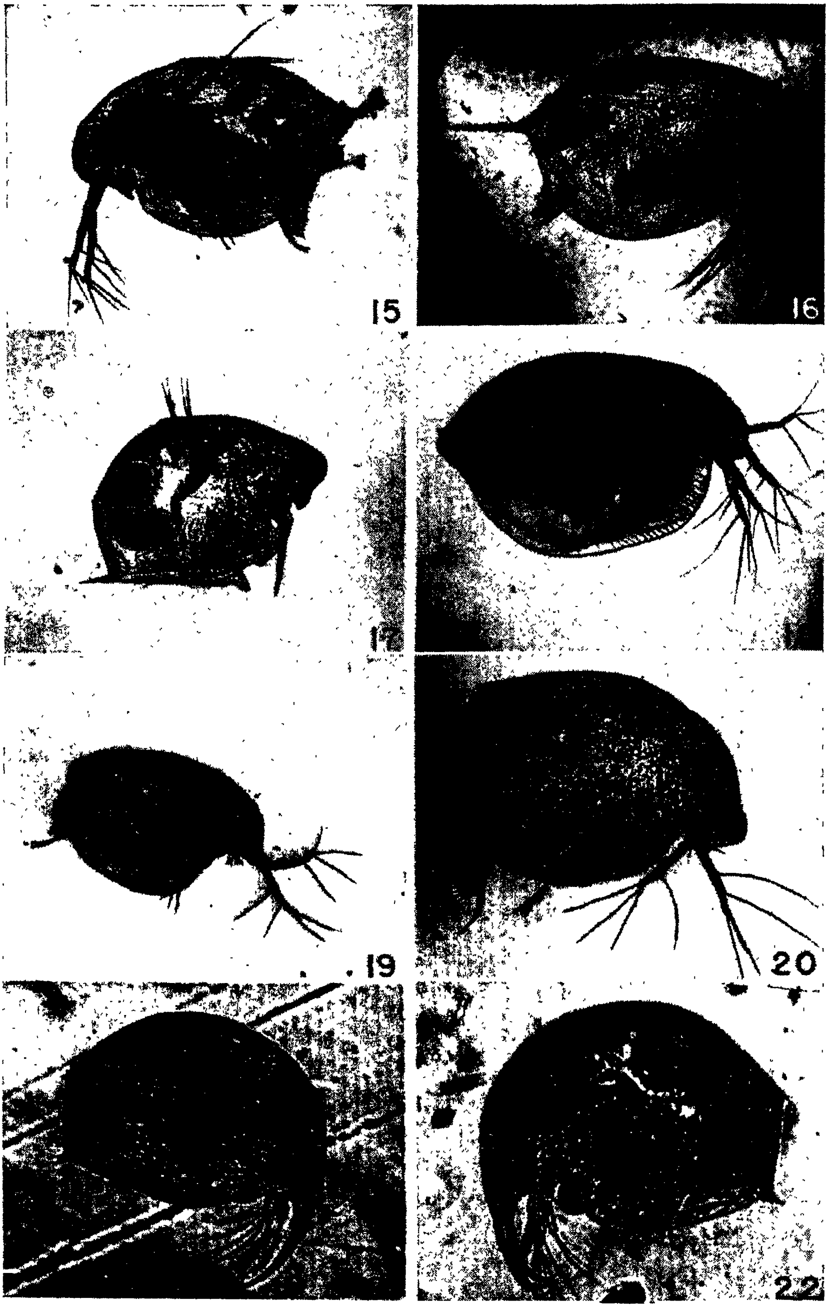
Plate III, Fig. 17.

Daphne mucronata Müller, Zool. Dan. Prod. No. 2404, Entromostraca, p. 94, figs. 6, 7. 1785.

Scapholeberis mucronata, Schodler, Branchiopoden der Umgegend von Berlin, p. 18. 1858.

Recognition characters: Body small, quadrate; head and ventral margins of carapace dark brown to black; ventral margin of carapace setose and extended into a sharp point or spine; post-abdomen short and broad, anus terminal; seven or fewer anal spines; post-abdominal claw denticulate, never pectinate.

Local occurrence and ecology: *S. mucronata* has not been previously reported for Kansas, but it occurrs commonly in eastern Kansas in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temporary pools in spring and summer, being most abundant in vernal waters. Clear pools are frequently so thickly populated with *S. mucronata* that individuals can easily be seen with the unaided eye. *S. mucronata* seems to prefer the surface of water and is frequently seen swimming on its back with its ventral surface just under the water. *S. mucronata* is a rapid swimmer, darting through the water with quick powerful strokes. Large numbers of individuals have been collected from roadside ditches, pasture pools and oxbow lakes.

General distribution: Common everywhere in Europe and America (Birge, 1918: 699).

Simocephalus vetulus (O. F. Müller)

Plate III, Fig. 18.

Daphne vetula Müller, Zool. Dan. Prod., p. 199. 1776.

Simocephalus vetulus, Schödler, Branchiopoden der Umgegend von Berlin, p. 18. 1858.

Recognition characters: Body transparent, irregularly quadrate, terminating posteriorly in short, bluntly rounded, indistinct spine, located on dorsal half posterior margin; antennules small, not hidden by rostrum; cervical sinus deep; slight concavity on dorsal margin of head just above eye; vertex rounded; ocellus elongated, reaching from base of eye almost to tip of rostrum; post-abdomen large, truncate, anus terminal; anal spines, ten or fewer, increasing in size distally; post-abdominal claw long, not pectinate; length variable, from 1.5 mm. to 2.7 mm.

S. vetulus is often confused with *S. serrulatus* since the two species resemble each other closely and are frequently found together in the same pool.

PLATE III

Fig. 15. Daphnia pulex, adult ♀ x 30, taken from roadside ditch 2½ miles SE Lawrence, Kansas, March, 1948.

Fig. 16. Daphnia longispina, adult ♀ x 36, collected from open water of Lone Star Lake 12 miles SW Lawrence, Kansas, April, 1948.

Fig. 17. Scapholeberis mucronata, adult ♀ x 38, taken from Potter's lake, University of Kansas campus, May, 1948.

Fig. 18. Simocephalus vetulus, adult ♀ x 22, taken from Potter's Lake, University of Kansas campus, April, 1948.

Fig. 19. Simocephalus serrulatus, adult ♀ x 30, from laboratory culture, April, 1948.

Fig. 20. Ceriodaphnia reticulata, adult ♀ x 41, from oxbow lake 2¼ miles NE Lawrence, Kansas, April, 1948.

Fig. 21. Bosmina longirostris, adult ♀ x 75, taken from open water of Potter's lake, University of Kansas campus, April, 1948.

Fig. 22. Bosmina longirostris, adult ♀ x 85, taken from open water of Potter's lake, University of Kansas campus, April, 1948.
Magnifications are approximate.

Simocephalus serrulatus (Koch)

Plate III, Fig. 19.

Daphnia serrulata Koch, Deutschlands Crustaceen, heft 35, taf. 14, Regenburg. 1841.

Simocephalus serrulatus, Leydig, Naturgeschichte der Daphniden, p. 165. Tubingen. 1860.

Recognition characters: Body transparent, distinctly quadrate, terminating posteriorly in short, bluntly rounded spine, located on dorsal half of posterior margin; antennules small, not hidden by rostrum; cervical sinus deep; slight concavity on dorsal margin of head just above eye; vertex pointed, armed with short spines; ocellus rhomboidal to triangular, rarely if ever elongated; post-abdomen large, truncate, anus terminal; 8 to 12 anal spines, increasing in size distally; post-abdominal claw long and unarmed; length variable, from 1.75 mm. to 3.0 mm.

Local occurrence and ecology: Since the two species of *Simocephalus* are found in eastern Kansas under the same conditions they will be discussed together. Neither of the species has been reported previously for Kansas, but both commonly occur in temporary pools in eastern Kansas in spring and fall. Both species appear to be sporadic in occurrence, suddenly appearing in a pool and remaining in great abundance for a week or two then disappearing as suddenly as they appeared. Similar occurrences have been observed in laboratory aquaria. These animals seem to survive equally well in slightly acid or alkaline water and are not greatly affected by temperature. Their food consists largely of diatoms and other micro-organisms.

General distribution: Common in Europe and America; Birge (1918: 689, 699) lists both species of *Simocephalus* as common everywhere in weedy water. Hoff (1943: 89) states that the two species have in general the same local distribution and habitat range, but that *S. serrulatus* occurs in a slightly higher percentage of collections than *S. vetulus.*

Ceriodaphnia reticulata (Jurine)

Plate III, Fig. 20.

Monoculus reticulatus Jurine, Histoire des Monocles qui se trouvent aux environs de Geneve, 14: 139, figs. 3, 4. 1820.

Ceriodaphnia reticulata, Dana, Crustacea, in United States Exploring Expedition, during the years 1838-1842, under the Command of Charles Wilkes, U.S.N., 13: 1630. 1852.

Recognition characters: Carapace distinctly rounded, reticulated; valves joined below ventral half of posterior margin, forming slight angle; antennules short, provided with median sensory hair; cervical sinus deep;

head long with prominent fornices; ocellus small; post-abdomen short and broad, anus terminal; 7 to 10 anal spines; post-abdominal claw pectinate proximally and denticulate distally.

Local occurrence and ecology: Common in vernal and autumnal temporary pools in eastern Kansas, but not previously reported for Kansas. *C. reticulata* frequently occurs in pools with *Scapholeberis mucronata.* *C. reticulata* is transparent and not readily detected with the unaided eye, but is as abundant in pools as the more easily seen *mucronata.* Unlike *mucronata, reticulata* prefers deeper water in which it moves about with slow, short strokes of the antennae. *C. reticulata* tends to congregate in large numbers around vegetation near the shoreline.

General distribution: Europe; eastern and central America (Blake, 1935: 385).

Moina rectirostris (Müller)

Daphnia rectirostris, Müller, Entomostraca, p.92, t.12, figs.1,2, 1785.

Moina rectirostris, Baird, British Entomostraca, p.101, t. xi. figs.1,2. 1850.

Recognition characters: Carapace well rounded, distinctly separated from head by deep cervical sinus; rostrum and ocellus absent; post-abdomen; anal spines seven to 11, the more distal spines bidentate; post-abdominal claw pectinate; the broad sac may become so distended with eggs or young as to appear to be a separate structure from the rest of the carapace.

Local occurrence and ecology: Not previously reported for the state; *M. rectirostris* was collected from a drainage ditch under a railroad trestle approximately two and one-half miles southeast of Lawrence, Kansas, from August 3 to 15, 1947, in water with a temperature range from 28 to 32 degrees C., and a hydrogen ion concentration of 6.9. Individuals were so abundant in the shallow parts of the ditch as to be easily visible to the unaided eye. The ecology of this species has not been thoroughly studied.

General distribution: Widely distributed in Europe and America in muddy pools (Birge, 1918: 705).

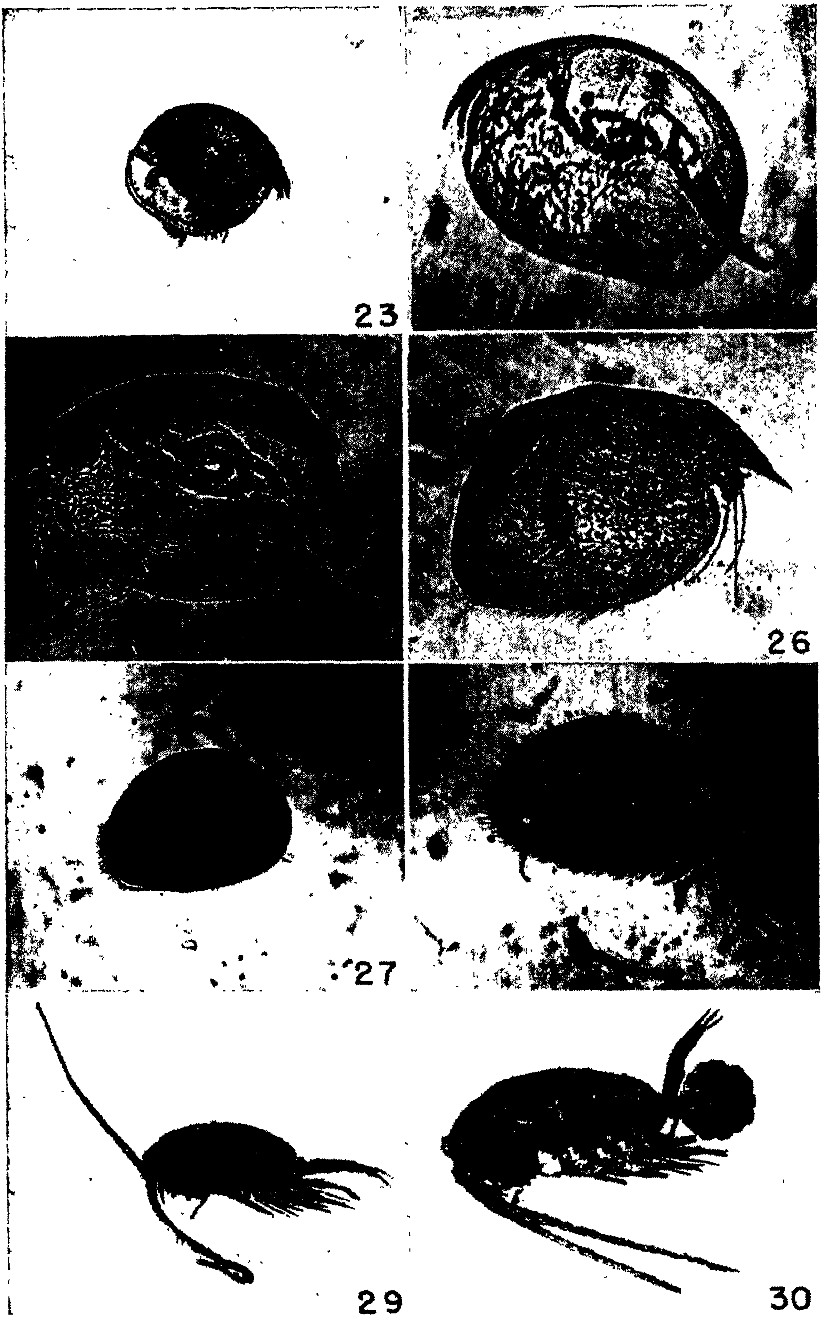
Bosmina longirostris (O. F. Müller)

Plate III, Figs. 21, 22.

Lynceus longirostris Müller, Entomostract, 10: 76, figs. 7, 8. 1785.

Bosmina longirostris, Baird, British Entomostraca, 15: 105, fig. 3. 1850.

Recognition characters: Carapace small, strongly arched dorsally; antennules variable in shape, curved or recurved; posteroventral spine short; post- abdomen divided by anal opening, truncate; post-abdominal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claw bearing two series of spinules, basal spinules increasing in length distally becoming very fine denticles at tip of claw.

Local occurrence and ecology: Not previously reported for Kansas; *B. longirostris* has been taken from the open water of a small pond on the University of Kansas campus, but not from the weedy shoreline area. *B. longirostris* swims in large groups on the surface of the water. Water samples collected in a Birge cone net may have a film of *B. longirostris* on the surface of the water in the vial. *B. longirostris'* swimming movements are sluggish, consisting of short strokes of the antennae. Individuals caught in the surface film cling together in groups, sometimes end-to-end in long chains. In a water sample they are easily detected since they are most often held on the surface of the water by surface tension. This species nas been collected in April in eastern Kansas. Its ecology has not been carefully studied. However, its food appears to be floating debris and planktonic microorganisms.

General distribution: Common in Europe and America; Birge (1918: 706) states that *B. longirostris* is very common in open waters of lakes and in weedy margins of pools and marshes. Hoff (1943: 92) reports that the species was found widespread in Reelfoot Lake, Tennessee, most abundantly in early summer, and more often than not associated with vegetation.

KEY TO GENERA AND SPECIES OF CHYDORIDAE IN EASTERN KANSAS

1. Body, seen from the side, irregularly spherical ....Genus *Chydorus* 2
   Body, seen from the side, elongate or oval, not spherical,.. 3
2. Body less than 0.5 mm. in length; post-anal part of post-abdomen nearly square, truncate ....*Chydorus sphaericus*
3. Post-abdominal claw with two spines at base; post-abdomen slightly widened at distal end, armed with a cluster of spines .... Genus *Pleuroxus*
   Post-abdominal claw long and slender, with or without a basal spine; post-abdomen conspicuously enlarged with long spines in groups with small spines, distal group of spines extremely long ....Genus *Leydigia* 5

PLATE IV

Fig. 23. Chydorus sphaericus, adult ♀ x 45, taken from Potter's lake, University of Kansas campus, April, 1948.
Fig. 24. Kurzia latissima, adult ♀ x 90, taken from railroad fill ditch 2¼ miles SE Lawrence, Kansas, April, 1948.
Fig. 25. Leydigia quadrangularis, adult ♀ x 100, from laboratory culture, December, 1947.
Fig. 26. Pleuroxus denticulatus, adult ♀ x 95, taken from railroad fill ditch 2¼ miles SE Lawrence, Kansas, May, 1948.
Fig. 27. Physocypria pustulosa, adult x 50, collected from Potter's lake, University of Kansas campus, May, 1948.
Fig. 28. Cypridopsis vidua, adult x 70, collected from roadside ditch 2¼ miles SE Lawrence, Kansas, May, 1948.
Fig. 29. Diaptomus clavipes, adult ♂ x 20, taken from drainage ditch 2¼ miles NE Lawrence, Kansas, October, 1947.
Fig. 30. Diaptomus clavipes, adult ♀ x 30, collected from drainage ditch 2¼ miles NE Lawrence, Kansas, October, 1947.
Magnifications are approximate.

Post-abdominal claw long, straight, with a signal basal spine and a series of small denticles terminating in a larger one about the middle of the claw, very fine teeth thence to apex; post-abdomen long and slender, armed with numerous marginal denticles .... Genus *Kurzia* 6

4. Posteroventral margin of carapace armed with three or four teeth.......... *Pleuroxus denticulatus*

5. Post-abdominal claw with a single basal spine; eye smaller than ocellus .... *Leydigia quadrangularis*

6. Post-abdomen with 10 to 12 marginal denticles; length of post-anal part of post-abdomen not less than three times its width .... *Kurzia latissima.*

Chydorus sphaericus (O. F. Müller)

Plate IV, Fig. 23.

Lynceus sphaericus Müller, Schrift. d Berlin Gesellsch. Nat. Fr. 6: 185-192. 1785.

Chydorus sphaericus, Baird, British Entomostraca. p. 126. 1850.

Recognition characters: Body irregularly spherical, nearly quadrate, strongly arched dorsally, tapering sharply postero-ventrally; antennules stout, not extending beyond rostrum; post-abdomen short with eight marginal denticles; post-abdominal claw small; basal spine of claw minute; size, not exceeding 0.5 mm. in length; color light yellow; valves reticulated.

Local occurrence and ecology: Not previously reported for Kansas; *C. sphaericus* occurs commonly in temporary and permanent pools in eastern Kansas in spring. *C. sphaericus* is a rapid swimmer, frequently swimming on its back with short, strong strokes of the antennae. Large numbers of individuals may be taken in a single collection. There seems to be little particular habitat preference since this animal has been collected from open water as well as in weedy areas.

General distribution: Found all over the world; *C. sphaericus* is the commonest of all Cladocera (Birge, 1948: 732).

Kurzia latissima (Kurz)

Plate IV, Fig. 24.

Alonopsis latissima, Kurz, Dodekas neur Cladoceren, 40, t. ii, figs. 13-15. 1874.

Recognition characters: Body subquadrate, greatly compressed, dorsally arched; valves crested, marked with longitudinal striations; antennules long and slender, not extending beyond rostrum; post- abdomen long and slender, armed with 10 to 12 marginal denticles, lower angle produced into lobe; post-abdominal claw long, straight, armed with single basal spine and series of small denticles terminating in larger one about middle of claw, very fine teeth thence to apex; length variable, usually not more than 0.5 mm. to 0.7 mm.

Local occurrence and ecology: Not previously reported for Kansas; *K. latissima* has been collected in large numbers in spring and fall in temporary vernal and autumnal pools in eastern Kansas. These pools are usually not overgrown with weeds. Cultures maintained in the laboratory have carried on reproduction sporadically throughout the year. Cultures kept in a refrigerator at 6 degrees C. carried on reproduction about as frequently as those kept at room temperature. Examination of intestinal contents of individuals indicates that diatoms and other micro-organisms make up the diet of *K. latissima.*

General distribution: Found in all regions of the world (Birge, 1918: 718). Hoff (1943: 96) states that this species occurs throughout the summer in Reelfoot Lake, Tennessee, seldom associated with heavy beds of vegetation.

Leydigia quadrangularis (Leydig)

Plate IV, Fig. 25.

Lynceus quadrangularis Leydig, Naturgeschichte der Daphniden (Crustacea Cladocera). pp. IV, 252. Tubingen. 1860.

Leydigia quadrangularis, Kurz, Dodekas neuer Cladoceren, 52, t. ii, fig. 1. 1874.

Recognition characters: Body oval, carapace broader posteriorly than anteriorly, strongly compressed; post-abdomen conspicuously large, armed with clusters of long and short spines along margin, spines greatly elongated distally; single basal spine on long slender post-abdominal claw.

Local occurrence and ecology: *L. quadrangularis* has not been reported previously for Kansas, but has been collected in small numbers in vernal and autumnal pools in eastern Kansas. In water taken from a roadside ditch two and one-half miles southeast of Lawrence, Kansas, November 12, 1947, and kept in the laboratory two specimens of *L. quadrangularis* were observed after about two weeks. In water taken from an oxbow lake two and one-quarter miles northeast of Lawrence, Kansas, March 16, 1948, 25 individuals appeared over a period of two to three weeks. Since these water samples were carefully examined when first brought into the laboratory it may be assumed that eggs present in the samples hatched in the laboratory. The ecology of this species has not been carefully studied.

General distribution: Not common; found singly among weeds in all regions in America (Birge, 1918: 721).

Pleuroxus denticulatus Birge

Plate IV, Fig. 26.

Pleuroxus denticulatus Birge, Wisconsin Acad. Sci. Arts and Ltrs., 4 (for 1876-77): 96-97, pl. I. fig. 21. 1879.

Recognition characters: Carapace elongated and dorsally arched, posterior margin greatly reduced in length; ventral margin of valves fringed with long setae; posteroventral margin armed with three or four teeth; antennules short, not reaching to base of long straight rostrum; post-abdomen short and broad, armed with marginal denticles only; post-abdominal claw with two basal spines.

Local occurrence and ecology: Not previously reported for Kansas; *P. denticulatus* is common in vernal and autumnal pools and ponds in eastern Kansas. Collections of this animal have been taken from ditches along railroad fills and roadsides. It is most common in weedy pools, frequently occurring in large numbers in water having a wide range of temperature and pH.

General distribution: Common everywhere in America in weedy water (Birge, 1918: 728). Hoff (1943: 95) states that *denticulatus* is present throughout the summer in widely separated areas in Reelfoot Lake, Tennessee, being found in largest numbers in samples from *Heteranthera* and pondweed beds.

Cypridopsis Vidua (O. F. Müller)

Plate IV, Fig. 28.

Cypris vidua Müller, Zool. Dan. Prod. No. 2384. 1776.

Cypridopsis vidua, Brady, Monograph on Recent British Ostracoda, Trans. Lin. Soc., 26: 353. 1868.

Recognition characters: Shell well arched, tumid, very setose; erect setae standing out from surface of shell, giving it a hairy appearance; four dark green or black color bands extending from dorsal border of shell almost to ventral margin of shell; single median eye large; a strong swimmer.

Local occurrence and ecology: Not previously reported for Kansas; *C. vidua* occurs abundantly in most ponds, pools and lakes in eastern Kansas, especially in spring; present in summer and fall pools but not in large numbers. *C. vidua* is a bottom feeder, straining micro-organisms from the water as it creeps along. In the laboratory it has been observed to swim rapidly up to the surface of the water in an aquarium then sink slowly to the bottom of the aquarium. It frequently appears in samples of pond water which have been in the laboratory for two or three weeks

although no adults were observed when the sample was originally collected and examined.

General distribution: Type locality, Europe, but common in America. Hoff (1942: 153) states that this species is common throughout the Holartic region and has been reported from the Neotropical region as well. Sharpe (1918: 807) reports that *C. vidua* is very common wherever algae are present.

Physocypria pustulosa (Sharpe)

Plate IV, Fig. 27.

Cypria pustulosa Sharpe, Bull. Illinois Lab. Nat. Hist., 4: 414-482. 1897.

Physocypria pustulosa, Müller, G. W. Ostracoda. Des Tierreich, 31: 434. 1912.

Recognition characters: Shell small, irregularly rounded; right of left valve marked with tubercles or pustules on anterior, ventral or posterior margin; three brown or reddish-brown patches on shell: one on median anterior border of shell, second on dorsal border and third patch on posterior border.

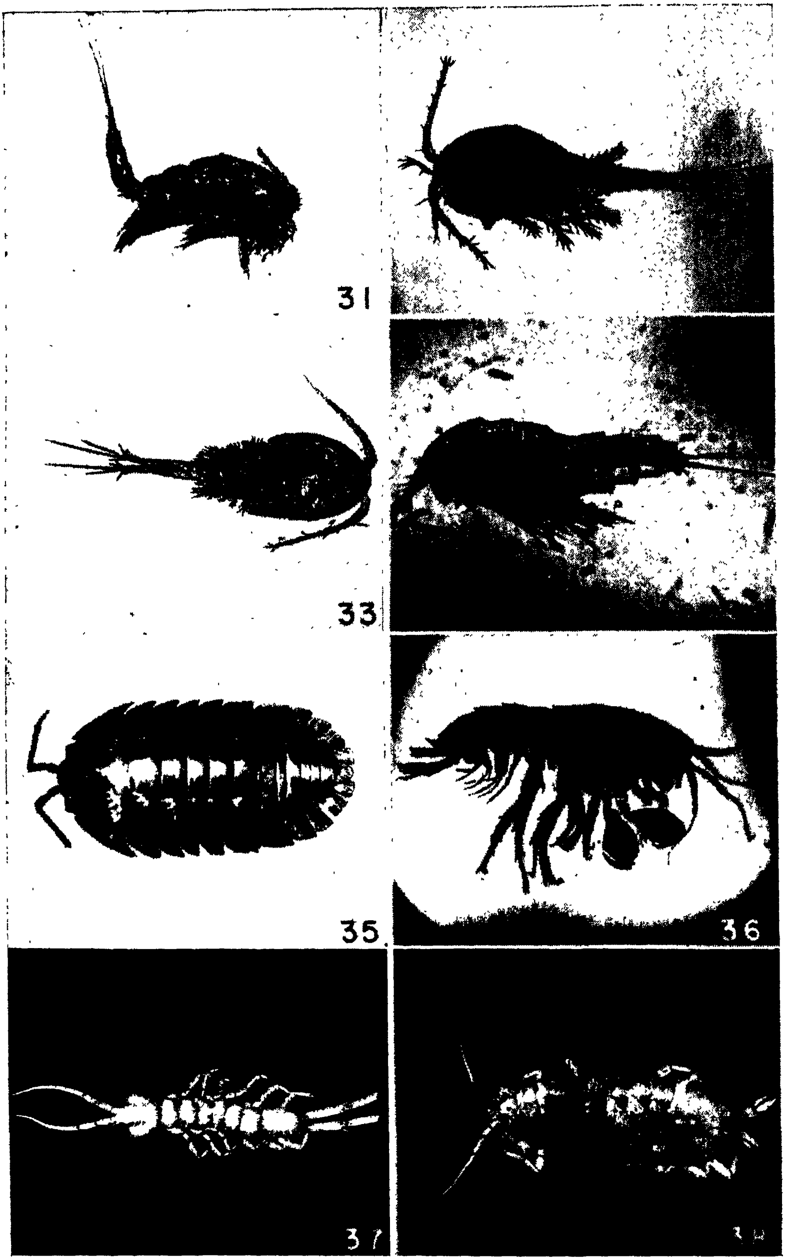
Local occurrence and ecology: Not previously reported for Kansas; *P. pustulosa* is common in eastern Kansas. Samples of water brought into the laboratory from southeastern and western Kansas indicate that the species is also common in those areas of the state. *P. pustulosa* occurs more frequently in pools with thick vegetation although collections of it have been taken from open water. It is most abundant in temporary waters between the months of April and June. A few individuals may be found in the fall. *P. pustulosa* is not predominately a bottom feeder, but has been seen frequently to rest on the bottom of aquaria in the laboratory. *P. pustulosa* has been found in water having a wide range of temperature and pH.

General distribution: Widely distributed in the United States; Hoff (1942: 125) states, "*P. pustulosa* has been reported under the names *P. globula* and *P. pustulosa* by Furtos (1933) from various places in Ohio. Dobbin records it as *Cypria* (*Physocypria*) *globula* from Washington and Alaska. It was reported from Illinois by Sharpe (1897) and Kofoid (1908)".

Diaptomus clavipes Schacht

Plate IV, Figs. 29, 30.

Diaptomus clavipes Schact, Bull. Illinois State Lab. Nat. Hist., 5 (for 1897-1901): 178-181, pl. XXXIV, figs. 1-3; pl. XXXV, figs. 1, 2. 1902.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Recognition characters: Body slender, cephalothorax and abdomen distinctly separated; first antennae with 25 segments; furcal rami short; fifth feet of male asymmetrical, biramous; first basal segment of right fifth foot of male armed with stout hook equal in length to first segment of exopodite; exopod of right fifth foot terminating in long sickle-shaped claw; antepenultimate segment of male right antenna with narrow, lateral hyaline lamella extending only slightly beyond segment if at all; body colored bright red, green or colorless.

Local occurrence and ecology: Note reported previously for Kansas; *D. clavipes* is common in temporary pools during the vernal and autumnal seasons in eastern Kansas. Frequently this animal is so abundant in shallow pools that the water seems to take on the color of their red bodies. It swims about near the surface of the water, engulfing large numbers of micro-organisms; this feeding behavior has also been observed in the laboratory. Debris in the water is usually rejected by quick, forceful movements of the swimming feet.

General distribution: Three known localities: West Okoboji Lake, Iowa; Nebraska, in the vicinity of Lincoln; and Greeley, Colorado (Marsh, 1918: 760).

Cyclops bicuspidatus thomasi (Forbes)

Plate V, Fig. 32.

Cyclops thomasi Forbes, Amer. Nat. 16: 649. August, 1882.

Cyclops bicuspidatus thomasi, Gurney, British Freshwater Copepoda, 3: 29-384. Ray Society London, 120. 1933.

Recognition characters: Body long and slender; first antennae composed of 17 segments; fifth feet of two segments, each with plumose bristle, distal segment also bearing lateral spine; furca and caudal bristles

PLATE V

Fig. 31. Cyclops vernalis, adult ♀ x 30, lateral view, collected from roadside ditch 2½ miles SE Lawrence, Kansas, April, 1948.

Fig. 32. Cyclops bicuspidatus thomasi, adult ♀ x 35, dorsal view, taken from railroad fill ditch, 2½ miles SE Lawrence, Kansas, April, 1948.

Fig. 33. Eucyclops agilis, adult ♀ x 33, dorsal view, collected from roadside ditch 2½ miles SE Lawrence, Kansas, May, 1948.

Fig. 34. Attheyella illinoisensis, adult ♂ x 40, lateral view, collected from shallow spring-fed stream, one mile NW University of Kansas campus, May, 1948.

Fig. 35. Armadillidium vulgare, adult ♂ x 4.5, taken from rock pile on University of Kansas campus, May, 1947.

Fig. 36. Hyalella knickerbockeri, adult ♂ x 13, taken from Potter's lake, University of Kansas campus, April, 1948.

Fig. 37. Caecidotea tridentata, adult ♂ x 2, taken from shallow spring-fed pool one mile NW of University of Kansas campus, April, 1948.

Fig. 38. Mancasellus ? sp., adult ♂ x 3, collected from roadside ditch 2½ miles SE Lawrence, Kansas, February, 1948.

Magnifications are approximate.

Transmitted June 21, 1948.

very long, small comb and lateral seta on furcal ramus.

Local occurrence and ecology: Not previously reported for Kansas; *C. bicuspidatus thomasi* is common in most bodies of water in eastern Kansas. Depth, temperature and pH of water appear to have little effect upon the presence of *thomasi* in pools since collections of it have been made under a wide variety of conditions. *C. thomasi* swims with quick strokes of the foliaceous swimming feet.

General distribution: Abundant in the Great Lakes and lakes of the northern states; common in certain bodies of water in North Carolina (Yeatman, 1944: 54).

Cyclops vernalis Fischer

Plate V, Fig. 31.

Cyclops vernalis Fischer, Bull. Soc. Nat. Moscou, 26 (1): 90, 2 pls. 1853.

Recognition characters: Body elongate, slender; never more than two mm. in length, exclusive of furcal setae; posterolateral angles of dorsum of next to last thoracic segment extended outward; posterior margins of abdominal segments usually not serrated, if so, very slightly; furcal rami without hairs; innermost terminal seta of furcal ramus shorter than furcal ramus; first antennae with 17 segments; aesthete at distal end of twelfth segment of fifth foot apical and jointed.

Local occurrence and ecology: Not previously reported for Kansas; *C. vernalis* occurs commonly in most temporary pools and ponds in eastern Kansas in vernal, estival and autumnal seasons, and is especially numerous in vernal and autumnal rain-pools. Samples of water taken from pools in winter usually contain no adult individuals of this species, but after one or more weeks in the laboratory adults have been observed swimming about in the water. It may be assumed that eggs in the water hatched in the laboratory.

General distribution: Widely distributed in America; found from Arctic Alaska to southern Mexico and from the Atlantic to the Pacific Ocean (Yeatman, 1944: 34).

Eucyclops agilis (Koch)

Plate V, Fig. 33.

Cyclops agilis Koch, Deutschlands Crustaceen, 21: 11. 1838.

Recognition characters: First antennae with 12 segments; lateral margin of furcal rami of female bearing row of spines; furcal rami long. The presence of a row of spines on the lateral margin of each furcal ramus on this animal separates it from all other copepods (Hoff, 1944: 23).

Local occurrence and ecology: Not previously reported for Kansas.

E. agilis occurs frequently in shallow pools such as ditches along roadsides and railroad fills in eastern Kansas. It appears in spring, summer and fall, but is most abundant in spring. This animal has not been found during severe winter weather, but it may appear as early as February if the water is not frozen. It apparently reaches its peak of reproduction in May, decreasing in numbers during the summer months when the water in most pools in eastern Kansas has dried-up or is very low.

General distributions "Found everywhere the world over" (Marsh, 1918: 779).

Attheyella illinoisensis (Forbes)

Plate V, Fig. 34.

Canthocamptus illinoisensis Forbes, Bull. Illinois Lab. Nat. Hist. 1 (for 1876-83): 14-15, figs. 23, 26, 27, 31. 1884.

Recognition characters: Body slender and cylindrical, urosome passing insensibly into metasome; first antennae of male composed of seven segments; fourth very short, anterior angle of third produced, the blunt process bearing three long bristles surrounding a slender olfactory club which is as long as the three following segments; penultimate segment of first antenna of male bearing strong spine or slender appressed process at middle of posterior margin; distal segments forming a grasping organ; first antennae of female composed of eight segments; fifth pair of feet, best developed in female, having sub-elliptical basal segment with basal half produced externally into a broad, triangular process bearing second segment on posterior margin; free end of basal segment bearing six large plumose bristles of which inner is longest; second or outer segment of fifth foot ovate, sub-truncate, spined on each margin and bearing four plumose bristles at tip and one at center of outer margin.

Local occurrence and ecology: Not previously reported for the state. *A. illinoisensis* has been found during the spring at two localities in eastern Kansas: a shallow pool near a drainage ditch two and one-quarter miles northeast of Lawrence, Kansas and a very shallow stream fed by a spring about one mile northwest of the west edge of the University of Kansas campus. *A illinoisensis* apparently is not common in eastern Kansas. Little is known about its ecology in eastern Kansas; however, it is worthy of note that both localities from which *A. illinoisensis* was taken were shallow pools; in the one instance, running water and the other, standing, but not stagnant water.

General distribution: Found in a pool fed by a slowly running spring in March and April at Normal, Illinois (Forbes, 1876: 16).

Mancasellus ? sp.

Plate V, Fig. 38.

Recognition characters: Body depressed, dark gray in color with splotches of lighter color; head fused with first thoracic segment; eyes sessile; first antennae short, basal portion composed of two segments, flagellum of seven or eight segments; second antenna long, composed of basal portion of four segments and flagellum of numerous proximal ring-like segments and elongate distal segments; mandibles lacking palps, but with a stout chisel-like process on inner margin, and distal portion bearing four to seven teeth; thoracic segments closely articulated, lateral margins fringed with short setae; seven pairs of thoracic appendages, first pair subchelate; propodus of male gnathopod enlarged, bearing three distinct tooth-like processes on the anterior margin; first process small and rounded, second or middle process approximately three times as long as first, third or distal process approximately four times as long as first; uropods terminal, biramous; first and second pleopods of male free; dactyli of last six pairs of thoracic appendages uniungiculate.

Local occurrence and ecology: Not previously reported for Kansas. This isopod is found commonly along the borders and on the bottom of most shallow bodies of water in eastern Kansas. It is a bottom feeder, crawling along on blades of grass and other bottom growing vegetation in pools. Large numbers of this animal may be found in groups under decaying vegetation on the bottom of pools and streams. Examples have been collected under a wide variety of conditions. It is very abundant in the spring, disappearing in the summer when pools dry-up and reappearing in the fall shortly after the first fall rains.

General distribution: Unknown. A communication from Dr. Leslie Hubricht (August 9, 1947) states that the genus *Mancasellus* is being revised and that a new generic name will then be available for local examples of this animal.

Caecidotea tridentata Hungerford

Plate V, Fig. 37.

Caecidotea tridentata Hungerford, Kansas Univ. Sci. Bull. 14: 175-181, 1 pl. October, 1922.

Recognition characters: Body long, narrow and chalky white; head large, wider than long but narrower than first thoracic segment; first antennae or antennules composed of basal portion of three segments and flagellum of 12 to 18 segments; second antennae relatively large, consisting of basal portion of six segments and flagellum of numerous closely joined segments; mandibles bearing large flattened palp of three segments and

two chitin-tipped processes, one with chisel-like cutting edge and other equipped with four to seven teeth; thoracic segments loosely articulated, lateral margins fringed with short stout setae; seven pairs of legs on thorax, first pair subchelate; propodus of first foot on male enlarged, with prominent processes on anterior margin, one at base and two near distal end of margin; dactyli of last six pairs of thoracic appendages uniungiculate; telson longer than wide; uropods twice as long as telson and composed of long basal segment and two terminal branches of unequal length.

Local occurrence and ecology: This animal is fairly common in cisterns, wells, springs, and shallow rocky streams in eastern Kansas. Hungerford (1922: 175-181) described this species from a cistern in Lawrence, Kansas and states (p. 178) that specimens in the National Museum, Washington, D. C., were collected in Topeka, Kansas, April 9, May 4, 12, and 29, 1912 and donated by E. A. Popenoe. Specimens of *C. tridenta* were invariably collected under decaying vegetation or rocks in localities where they were found. When the vegetation or rocks under which *tridentata* was hiding were moved, individuals were seen to crawl away in search of new cover. Although eyes are absent in this animal, it seems sensitive to light. Individuals exposed to light in a laboratory aquarium, free from dead vegetation or other materials which might offer protective covering, were observed to crawl rapidly about on the bottom of the aquarium moving the antennae furiously. When leaves or stones were added to the aquarium, these individuals immediately took refuge under them. This behavior might be explained as a tactile response. Hoffman (1933: 31) reports that *C. tridentata* feeds upon insects and Crustacea that fall into and die in water, and that it is often cannibalistic.

General distribution: Unknown.

Armadillidium vulgare (Latreille)

Plate V, Fig. 35.

Armadillo vulgare Latreille, Hist. Crust., 7: 48. 1805.

Armadillidium vulgare, Budde-Lund, Crustacea Isopoda Terrestria per families et genera et species descripta, pp. 1-319. Hauniae. 1885.

Recognition characters: Body oval, depressed, more than twice as long as broad, first antennae rudimentary; second antennae short; uropods terminal, exopod large and lamellar, inner branch narrow and elongate, but not extending beyond extremity of abdomen; body colored dark gray or brown, splotched with lighter colored areas.

Local occurrence and ecology: Not previously reported for Kansas. *A. vulgare* occurs in damp places in the spring and fall. It is found under

rocks and decaying vegetation, in gardens and basements and other situations that afford moisture and shelter. Activity is confined to spring, summer, and fall. In eastern Kansas, apparently *A. vulgare* hibernates about the time of the first frost, reappearing as early as February if the ground thaws. These animals are terrestrial in habit.

General distribution: "Old World origin, but now found throughout much of the world inhabited by civilized man" (Van Name, 1936: 278); "Entire America; cosmopolitan; under stones, in damp places" (Blake, 1935: 443); "World wide in distribution" (Richardson, 1905: 666).

Hyalella knickerbockeri (Bate)

Plate V, Fig. 36.

Allorchestes knickerbockeri Bate, Cat. Amphip. Crust. Brit. Mus., p. 36. pl. VI. 1862.

Hyalella knickerbockeri, Smith, Rept. U.S. Fish Comm. 1872-73, p. 645-647, pl. 11. 1874.

Recognition character: Body laterally compressed; first thoracic segment united with head; seven pairs of free thoracic segments all bearing appendages of which first two pairs are subchelate, second pair much larger than first; periopods equipped with gills; last three pairs of pleopods adapted for jumping; posterodorsal margin of first two abdominal segments extended to form spines; first and second antennae long, second considerably longer than first.

Local occurrence and ecology: Not previously reported for Kansas. *H. knickerbockeri* occurs in pools well stocked with *Ceratophyllum.* Collections of *H. knickerbockeri* have been made from a permanent pool on the University of Kansas campus in spring, summer and fall. It is most abundant in the pond in spring in areas where vegetation is abundant. Dead stalks of *Typha* have long straight tubes in which *H. knickerbockeri* may live. This animal is a rapid swimmer, using the last three pairs of pleopods for jumping through the water. It feeds on micro-plankton.

General distribution: "In fresh-water ponds in eastern and central states, where it is one of the two common freshwater amphipods" (Pratt, 1935: 428). According to Ortmann (1918: 843) this species is found in rivers, ponds and lakes from Maine to Florida and California, southward into Central America.

Glossary

Aesthete—sensory hair on the first antenna of copepods.
Anal spines—spines bordering the anal opening, if distal to the anal opening, called post-anal spines.
Antenna—(-ae, plural) a jointed appendage of the head.
Antennule—(-s, plural) small antenna.
Antenniform—cylindrical, shaped like an antenna.

Antipenultimate—the third from the last segment of an appendage.
Apex—the tip of a process or structure.
Apical—of or pertaining to the apex of a process or structure.
Asymmetrical—without symmetry, the two sides being unlike.
Bidentate—possessing two tooth-like processes.
Bifurcate—divided into two forks or branches.
Biramous—having two rami or branches.
Bivalve—a shell composed of two lateral halves enclosing the body of some crustacea.
Branchial—pertaining to structures used in respiration.
Brood pouch—the dorsal portion of the carapace in the Cladocera; the basket formed by the flat projections of the thoracic legs of the isopods, used for carrying young.
Carapace— a shell-like covering of the anterior portion of the body of a crustacean.
Caudal—pertaining to the post-anal portion.
Cephalothorax—the fused head and thorax or chest region of the copepods.
Cercopods—tails or caudal extensions.
Cervical sinus—a grove between the head and carapace of the Cladocera.
Chelate—forming a pincer.
Cheliform—having the shape of a pincer.
Chitinous—containing chitin, a hard substance which forms the external skeleton of the Crustacea.
Clasper—the second antenna of the male fairy shrimp which is modified for grasping the female in mating.
Compressed—flattened, or reduced in breadth.
Confluent—flowing together.
Conical—cone shaped.
Dactylus—(-i, plural) toe or claw of walking feet of Crustacea.
Denticulate—possessing denticles or tooth-like processes.
Depressed—bent downward or dorsoventrally compressed.
Digitiform—shaped like a digit or finger.
Distal—away from the central axis of the body.
Ellipsoidal—oblong with rounded ends.
Endopodite—the inner branch of the biramous appendages of the Crustacea.
Exopodite—the outer branch of the biramous appendages of the Crustacea.
Filiform—having the shape of a thread or filament.
Foliaceous—leaf-like in shape.
Fornix—(-ces, plural) a supporting ridge over the antenna of some of the Cladocera.
Frontal appendage—an extension from the front of the head or base of the second antennae of the Anostraca.
Furca—(-ae, plural) a fork of the tail; same as cercopod.
Fusiform—spindle shaped.
Geniculate—knee-shaped, or bending like a knee at the joints.
Gnathopod—a modified thoracic appendage used in grasping or holding food.
Hyaline—transparent, glassy in appearance.
Lamella—a thin sheet or plate.
Laminate—plate-like in appearance.
Lobosity—having or appearing to have lobes.
Masticatory—pertaining to the grinding of food.
Metasome—the combined head and thorax segments of the copepods.
Natatory—used in swimming.
Ocellus—a simple immovable eye spot.
Olfactory club—a sensory spine on the antenna of some copepods.
Operculum—a covering or plate as for example, that covering the gills of the aquatic isopods.
Palp—a feeler or sensory organ attached to the jointed appendages.
Pecten—a comb or comb-like structure having processes resembling the teeth of a comb.
Pectinate—comb-like, having a pecten.
Penultimate—the next to the last segment of an appendage.

Periopod—a walking foot, or thoracic appendage.
Pleopod—abdominal appendage used for breathing, locomotion, or carrying eggs.
Plumose—feather-like, resembling a plume.
Podomeres—segments of an appendage.
Post-abdomen—the unjointed portion of the abdomen posterior to the swimming feet of the Cladocera.
Post-anal—distal to the anal opening.
Prehensile—adapted for grasping or holding.
Propodus—enlarged distal segment of the gnathopod.
Proximal—toward the central axis of the body.
Punctate—covered or studded with small depressions, pits, spots of color.
Pustule—an elevation resembling a pimple or blister.
Quadrate—four sided.
Ramus—(-i, plural) a branch.
Reticulated—netted, having the form or appearance of a net-work.
Retractile—capable of being withdrawn.
Rostrum—a beak or extension of the head.
Sessile—fixed or sedentary as for example, eyes without stalks.
Seta—(-ae, plural) a small hair-like process.
Setose—possessing setae.
Sigmoid curve—an S-shaped curve.
Spatulate—flattened, resembling a spatula.
Spinose—possessing spines.
Spinules—small spines.
Subchelate—ultimate segment of an appendage bent back upon the penultimate segment.
Subelliptical—not completely elliptical, suggesting ellipticalness.
Telson—the last body segment, usually modified.
Triarticulate—three jointed.
Trilobed—having three lobes.
Truncate—having the appearance of being broken off.
Tubercles—small rounded elevations resembling pimples, same as pustules.
Tumid—swollen, enlarged.
Ultimate—the last segment of an appendage.
Umbo—(-bone, plural) an elevation or prominence of a valve of a bivalve shell near the hinge.
Uniramous—having one branch.
Uniungiculate—having a single terminal claw.
Uropod—one of the last pair of pleopods, modified.
Urosome—the abdomen and furcae of the copepods.
Vertex—dorsum of the head.

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Lead-Silver Molds of the Osage Indians.

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The first mention of the Osage Indians in Missouri history occurred in 1673 when Pierre Marquette and Louis Joliet located by chance villages of the two most important tribes of the state—the Missouri and the Osage. In spite of the fact that the state was named after the Missouris, the Osage were the more important of the two tribes. It was the war-like nature of the Osage that gave early pioneers immense trouble in their settlement of the rich river-bottom lands of the area. The Missouris rapidly lost their power through a series of smallpox epidemics and by constant raids of Eastern tribes being pushed out of the East by the white man.

The late historic sites of the Osage, situated in Saline and Vernon counties, west central Missouri, have proved to be invaluable for the finding of historic Indian and European trade objects. Stone projectile points, scrapers, abrading stones, hammerstones, effigy, bowl pipes, and bone artifacts, are found in the excavations to be associated in some cases with flint-lock rifles, kettle fragments, copper crucifixes, porcelain and glass beads, all of European origin.

Among the numerous Osage artifacts recovered are several carved stone "molds". These "molds" represent carvings in sandstone, red siltstone, and white claystone, and have supposedly been used for casting small lead or silver ornaments[1].

One known technique of casting metal ornaments is given in an article by William H. R. Lynkins[2]:

> "Many years ago, when residing among the Indians of Kansas, I remember to have seen the young men make small ornaments by cutting figures in wood and filling them with melted pewter or lead, using a *wooden* ladle in which to melt the metal. A bowl-shaped cavity, with a lip or channel on one side, was cut in a very green piece of wood; the metal broken up and placed in the cavity, and a fire of hot coals placed upon top of the ladle, instead of under. In this rude and primitive way very passable figures of turtles, birds, horses, etc., were made. I have also seen handles of tomahawks and war-clubs very handsomely ornamented with geometrical figures in silver, in the same way using their old worn-out ornaments of silver for that purpose."

To date only six of these "molds" have been found or reported to the

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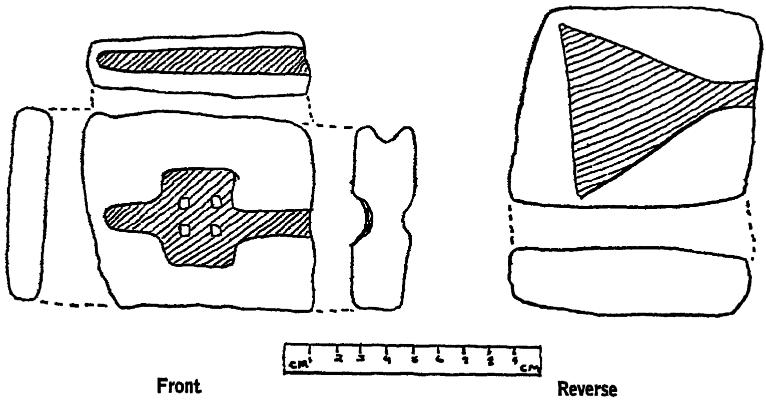
[1] Carl H. Chapman, "A Preliminary Survey of Missouri Archaeology. Part I. Historic Indian Tribes." *The Missouri Archaeologist*, Vol. 10, October, 1946, pp. 19-20.

[2] William H. R. Lykins, "On the Mound-Builders' Knowledge of Metals." *Kansas City Review of Science and Industry*, 1882, p. 535.

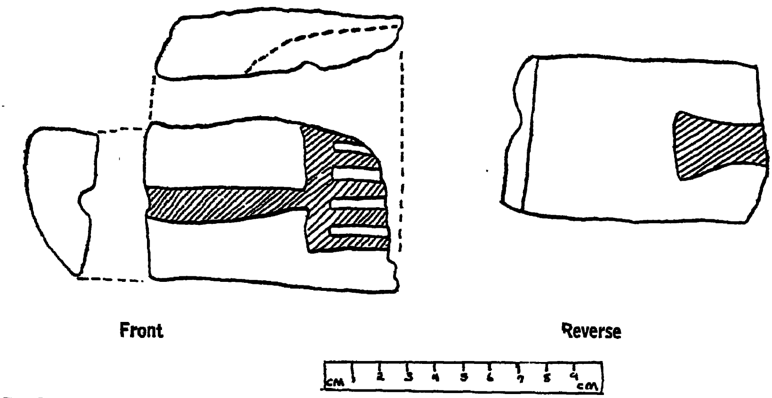
Missouri Archaeological Society or the Department of Sociology and Anthropology, University of Missouri.

Excavation of Osage sites has failed to reveal lead or silver ornaments which would duplicate any of the impressions carved in the stone "molds". Several small silver triangular ornaments have been found to bear the closest affinity to these mold impressions. A few copper crucifixes have also been encountered, but these are believed to be trade pieces.

Three "molds" from the Little Osage Village, Saline County, Missouri, were reported by Mr. J. M. Crick[8]. All three were surface finds.

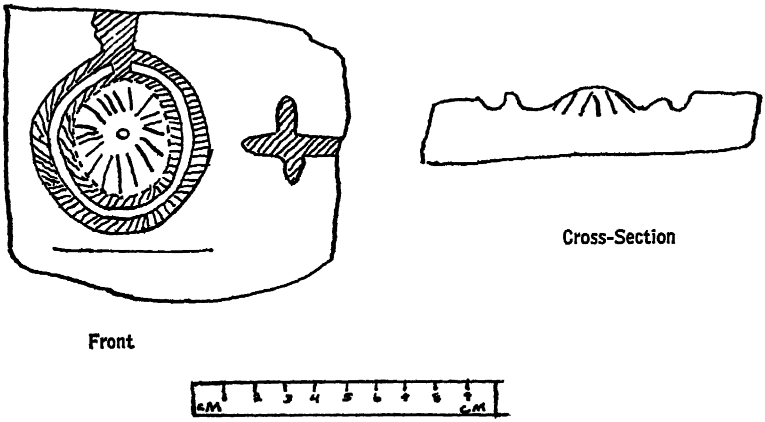


I. Carvings in red catlinite, approximately 1-2 mm. deep, except where the depressions rise up at the edge; the white islands in the center are 1 mm. square.



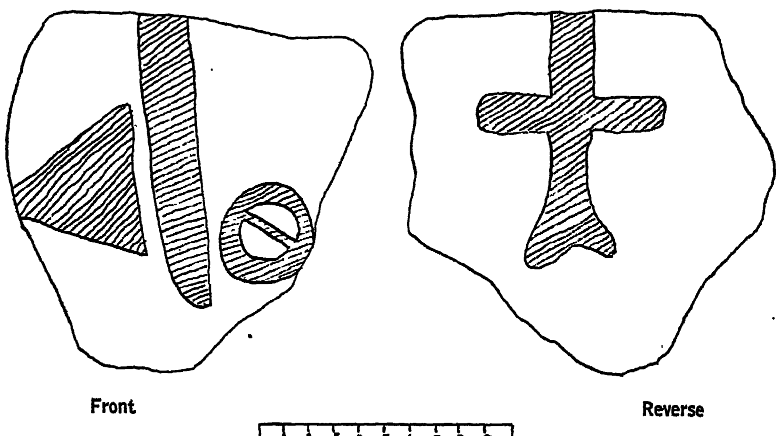
II. Fragmentary specimen of carved claystone, blue-gray in color. The mold cup on this specimen is about 3 mm. deep. Indications are that there must have been four islands on the front side; the uppermost island is almost gone due to the break. Reverse-side mold is 1 mm. deep.

[8] Permission for use of material granted by Mr. J. M. Crick, Corder, Missouri. These "molds" were retained by Mr. Crick in his personal collection.



III. Carvings in white siltstone. The depressions or mold cup is 1 mm. deep. The white area within the design is on the same level as the outer surface. The incised lines drawn toward the center are nineteen in number, with no particular order in length or depth. The incision below the central mold design is cut approximately 1 mm. deep and extends to the lower edge. No carvings or incisions are found on the reverse side. Notice the raised center of the design in the cross-section view.

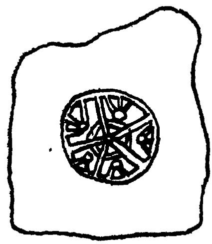
The fourth specimen[1] was found in 1947 by the author on an Osage site in Vernon County, while participating as a member of a University of Missouri field session.



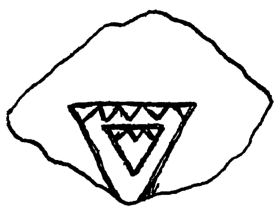
IV. Carvings in sandstone. The depressions are approximately 2 mm. deep and well defined. The crucifix-design on the reverse side is entirely different from any of the actual crucifixes thus far found. (Length of mold, 2 1-4 in.; width, 2 in.; thickness, 3-4 in.).

[1] Now located in the Museum of Anthropology, Switzler Hall, University of Missouri, Columbia, Missouri.

The remaining two "molds" have previously been described in a report on archaeological investigations of the Osage Indians[1].



V. Carving in red siltstone, in a circular design[2]. It should be noted that on this particular specimen the mold depression does not extend entirely to the edge of the artifact. Ornaments from this "mold" possibly were not made in the same process as indicated on the other specimens, where the design does extend to the edge of the surface to permit the excess metal to drip off.



VI. Triangular design carved in white claystone. It is a equilateral triangle open at one end; the sides are 11-16 of an inch in length. It contains another equilateral triangle within it, the sides of which are 5-16 of an inch in length. There are five small triangles at the base of the larger triangle and three at the base of the smaller triangle.

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[1] Brewton Berry, Carl Chapman, and John Mack, "Archaeological Remains of the Osage." *American Antiquity,* Vol. 10, No. 1, July, 1944, Plate 1.

[2] This specimen is in the possession of Mr. W. L. Brown, Walker, Missouri.

Determination Of Quercetin-Like Substances In Several Mid-Western Plants

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Quercetin and rutin are quite often associated with each other in plant material. On hydrolysis with dilute acid, rutin yields quercetin, rhamnose, and glucose in equimolar proportions. It was hoped that in determining quercetin-like substances in various plants in this area another source of rutin would be found.

Rutin is a comparatively new drug of widespread interest; yet rutin was first discovered in garden rue in 1842 and later by Schunk in 1860 who obtained the material from the fresh leaves of buckwheat[19]. In 1936 Szent-Gyorgi and his co-workers[1] were working on the extracts of Hungarian red peppers and bitter lemon peel. They observed in the extracts the presence of a substance other than ascorbic acid which appeared to possess anti-hemorrhagic properties. The substance was named Vitamin P (Vitamin of permeability) because it appeared to exert a specific regulating influence on the permeability of the vessels.

J. F. Couch and his co-workers[2] were searching for possible uses for tobacco by-products and were able to obtain rutin from a high-grade tobacco. As a result of J. F. Couch's suggestion in 1941 that rutin might reduce capillary fragility, clinical tests were made by J. Q. Griffith, Jr.[3]. These tests established the value of rutin for this purpose, thus attributing Vitamin P-like properties to rutin.

Several methods of isolating rutin from plants and plant products have been reported in the literature. These methods may be divided into two general types: (a) hot water extraction and (b) alcohol extraction using various alcohols and concentrations of various alcohols[2 4 5].

Investigators have used various methods for identification of rutin. A few of the methods are as follows:

A number of investigators have had good results by following the recommendations of Charaux[6] who noted the time necessary for the first crystals of quercetin to appear when the glycoside is hydrolyzed by dilute acid under rigidly specified conditions.

Sando and Lloyd[5] successfully identified rutin by using the method of Wunderlich[7] who showed that quercetin is formed quantitatively on acid hydrolysis.

Neuberg and Kobel[8] hydrolyzed rutin with dilute acid, crystallized and filtered off the quercetin, and determined the rotations of the filtrate.

The theoretical value may be calculated from the weight of the sample and a knowledge of the specific rotations of glucose and rhamnose.

Several color tests have been employed and found of value. Rutin and quercetin gives an intense green color with aqueous or alcoholic ferric chloride[7]. When rutin is reduced by treating with zinc and dilute hydrochloric acid in amyl alcohol, the solution turns red[9]. With glacial acetic acid and metallic magnesium in absolute alcohol at 35 degrees C. a reddish-purple color is formed; quercetin forms a green color with this test. This test may be used to distinguish rutin from quercetin[10]. These three color tests are employed by this author as means of identification.

Several methods for the quantitative estimation of rutin have also been devised.

Porter, Brice, Couch, and Copley[11] devised a spectro-photometric method for the determination of rutin and quercetin. Recently it was amended by Porter, Brice, and Couch[12], who recommend carrying out the measurements in 95% ethyl alcohol made acid (0.0002N) with acetic acid. Quercetin may be determined in the presence of rutin since its absorption spectrum is different.

A. J. Glasko et al.[13] described a method utilizing the fluorescence of rutin in the presence of boric acid.

A method has been developed by Englehemier, Geissman, Crowell, and Freiss[14] which involves the dropping mercury electrode.

Wilson, Weatherby, and Bock[15] have used the color formed by boric acid and citric acid in acetone for the quantitative determination. They measured the color with a Klett-Summerson photoelectric colorimeter. It was observed by Wilson, Weatherby, and Bock[16] that boric acid dried with lemon juice gave brilliant yellow coloration. Further work led to the conclusion that this coloration was produced by a reaction between the boric acid and a flavone or group of flavones similar in structure to quercetin. The color-forming substance, insoluble in chloroform, will dissolve in acetone saturated with boric acid to give a yellow coloration, the intensity of which can be quantitatively measured on a Klett-Summerson photoelectric colorimeter.

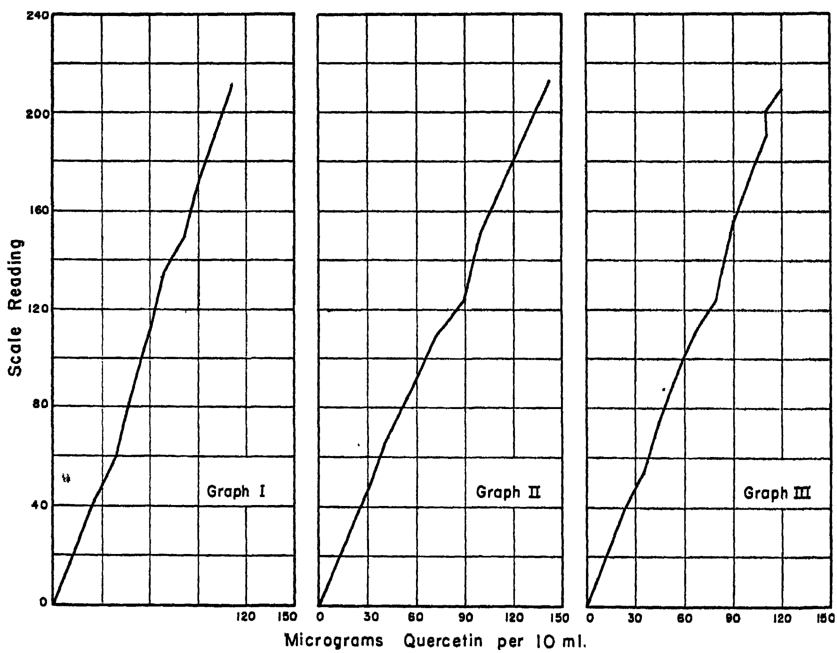
The method of Wilson, Weatherby, and Bock is the method here used for quantitative determination of quercetin-like substance.

Standardization

Weighed amounts (10-15 mg.) of quercetin (obtained from Eastern Regional Research Laboratory) which had been dried in a vacuum desiccator for 2 days, were dissolved in acetone and diluted to 100 ml. in volumetric flasks.

Borocitric reagent was prepared as follows:
Solution A—Absolute acetone 100 ml., anhydrous citric acid 10 grams.
Solution B—Absolute acetone 100 ml., boric acid to saturate.
Each solution is filtered. The two solutions separately are stable indefinitely[15].

A Klett-Summerson Colorimeter with a blue filter No. 42 was used for the standardization. A test tube was filled to the 10 ml. mark with a mixture of equal volumes of solutions A and B, and the zero point set for this reagent. The acetone-quercetin solution, to be used for the standardization, was then dropped into the test tube, using a serological pipet, graduated in 0.01 ml. divisions. From the readings on the colorimeter a response curve was made. After the addition of each 0.1 ml. the tube was removed from the instrument, shaken well to insure proper mixing and re-inserted and a reading taken. The reaction between quercetin and the borocitric reagent is very sensitive to moisture. It is reported that as little as 1% of moisture decreases the color response by half. Because of this sensitivity to moisture, all precautions must be taken to exclude the slightest traces of moisture. To prevent moisture absorption Wilson, Weatherby, and Bock suggested covering the lip of the test tube with tin foil (previously washed in acetone) when shaking the test tube.



As quercetin solution is itself yellow, it was necessary also to obtain a curve of colorimeteric response to the acetone-quercetin solution, free of the boroflavone reaction. This curve was obtained by mixing 5 ml. of solution A and 5 ml. of pure acetone and following the same procedure of adding quercetin in 0.1 ml. portions and taking a reading on the colorimeter. Thus a curve could be plotted for the true boroflavone with quercetin by subtracting the acetone-quercetin reading from the boro-citric-quercetin reading to give a net reading. From this curve was taken the data needed in establishing quercetin equivalents of the natural materials. It is advisable to repeat the curves for each lot of reagent.

Table I

Ml. of sol. added to 10ml. of reagent	Micrograms of quercetin per 10ml. of sol.	Scale Reading Borocitric	Scale Reading Citric Acid and acetone	Net Reading
GRAPH I — 12.4 mg. Quercetin/100 ml. of solution.				
0.1	12.3	24	5	19
0.2	24.3	48	9	39
0.3	36.1	73	14	59
0.4	47.7	101	18	83
0.5	59.0	129	21	108
0.6	70.2	155	25	130
0.7	81.1	178	28	150
0.8	91.9	204	30	174
0.9	102.5	228	32	196
1.0	112.7	246	34	212
1.2	132.9	288	37	251
GRAPH II — 11.0 mg. Quercetin/100 ml. of solution.				
0.1	10.9	19	3	16
0.2	21.5	40	7	33
0.3	32.0	60	11	49
0.4	42.3	80	13	67
0.5	52.4	99	18	81
0.6	62.3	116	22	94
0.7	72.0	133	24	109
0.8	81.5	150	26	124
0.9	90.8	164	28	136
1.0	100.0	181	30	151
1.1	109.0	195	32	163
1.2	117.9	210	34	176
1.3	126.5	224	36	188
1.5	143.5	252	39	213
GRAPH III — 12.1 mg. Quercetin/100 ml. of solution.				
0.1	12.0	28	7	21
0.2	23.7	52	14	38
0.3	35.2	73	18	55
0.4	46.5	99	22	77
0.5	57.6	124	26	98
0.6	68.5	144	30	114
0.7	79.2	167	32	135
0.8	89.6	189	34	155
0.9	99.9	210	37	173
1.0	110.0	230	39	191
1.1	119.9	250	41	209

Quercetin solution was added to 10ml. of reagent, but concentration of quercetin is calculated as micrograms per 10ml. of total solution.

Procedure of Determining Quercetin Equivalents In the Plants

All plants used in this problem except pie pumpkin, oat straw and wheat straw were identified by Ronald L. McGregor and Worthie H. Horr, of the botany department of the University of Kansas.

The following plants were extracted: 1.) *Helianthus annuus* (typical sunflower); 2.) *Helianthus tuberosus;* 3.) *Rumex altissimus* (Dock); 4.) *Solidago altissima* (Goldenrod); 5.) *Maclura porifera* (hedge-tree, osage orange); 6.) Pie pumpkin; 7.) Oat straw; 8.) Wheat straw.

The Rumex plant had died at the time of ~~the~~ collecting of these plants, thus it could not be used. However, the roots were used for extraction. Oat straw and wheat straw were taken from straw stacks of each and thus could not be properly dried. It was not possible to obtain the pie pumpkin till a few days after is was picked in late October, thus the pumpkin was not sliced and dried as soon as it should have been. The rest of the plants were picked and properly dried without delay. It is very important to dry harvested plants as quickly as possible to prevent serious loss of rutin, possibly caused by enzyme action, which occurs in a few hours if the cut plant is left lying in the field(17). The drying of plants must be rapid to avoid the serious loss of rutin that occurs during slow drying; when the plant is thoroughly dried the rutin content appears to be stable(17). The hedge-root and hedge-apples were gathered in October. The *Helianthus annuus, Helianthus tuberosus,* and *Solidago altissima* were gathered in late September while their flowers were in full bloom. Plants were weighed before drying and after drying so calculations could be based on fresh weight as well as dry weight.

After the plants were sliced (the ones needing it such as pie pumpkin and hedge-apple) and dried they were ground by using a Wiley mill The plants were stored in air-tight moisture-proof containers when samples were not being taken. Samples taken were generally around 5 grams. This was extracted with absolute methyl alcohol in a Soxhlet extraction apparatus. The extracted liquid was evaporated by an electric fan to remove the methyl alcohol. Chlorophyll, fats, resins, etc., were next removed from the dry extract by digestion with chloroform. Care had to be taken to keep an emulsion from forming. The mixture was then placed in a separatory funnel and the quercetin layer drawn off. The quercetin layer was dissolved in acetone, filtered, and diluted to 100 ml. in a volumetric flask.

The readings with borocitric reagent were made by taking sufficient of the acetone solution of the extract to give a reading in the desired range (suitably 100 to 250) and adding sufficient reagent to fill the tube to the 10 ml. mark.

Blank determinations were made, using the same quantities of the extracts and a mixture of equal parts of solution A and acetone. The net reading is the difference between these two sets of readings, and the quercetin equivalent value was the result of calculating the quantity found on the net curve back to the original material.

After agreeable results on flowers of *Helianthus tuberosus* were obtained, the accuracy of the procedure and technique were checked as follows: 4.20 mg. of quercetin was mixed with 4.08 grams of dried flowers of *Helianthus tuberosus* (representing 16.73 grams of fresh material). The fortified material was extracted using the same procedure previously outlined. A 0.5 ml. portion was taken from the final diluted volume of 100 ml. A net reading of 101 was obtained. This reading of 101 is equivalent to 56 micrograms of quercetin or 11.20 milligrams of quercetin for the 16.73 grams of the fresh leaves. According to calculations, this quantity of *Helianthus tuberosus* flowers contain 7.43 milligrams. The recovery of added quercetin was 11.20 - 7.24 or 3.96 milligrams. A loss of 4.20 - 3.96 or 0.24 milligram. This was a loss of 0.24/4.20 or 5 per cent.

Results

Table II shows the reading taken from the colorimeter and the final results. The table gives the results as the number of milligrams of quercetin-like substance per gram of fresh plant and also dry plant.

Flowers of *Helianthus annuus* contained 0.109 mg./Gm. of fresh plant and 0.429 mg./Gm. of dry plant; while the leaves of *Helianthus annuus* contained 0.063 mg./Gm. of fresh plant and 0.21 mg./Gm. of dry plant. The flowers of *Helianthus tuberosus* contained 0.433 mg./Gm. of fresh plant and 1.77 mg./Gm. of dry plant; the leaves of *Helianthus tuberosus* were a little better source in having 0.435 mg./Gm. of fresh plant and 1.97 mg./Gm. of dry plant. The tubers of *Helianthus tuberosus* only contained a trace. The extract of the rumex root was quite yellow to start with, which was perhaps due to anthroquinone derivatives. Rumex root contained 0.241 mg./Gm. of fresh plant and 0.556 mg./Gm. of dry plant. The tops of goldenrod were a good source having 4.63 mg./Gm. of fresh plant and 9.90 mg./Gm. of dry plant. The whole plant of Goldenrod (whole portion above ground) contained 3.67 mg./Gm. of fresh plant and 6.05 mg./Gm. of dry plant. Hedgewood gave negative results. Hedge-apple had 0.274 mg./Gm. of fresh plant and 0.519 mg./Gm. of dry plant; while Hedge-root contained 0.362 mg./Gm. of fresh plant and 1.13 mg./Gm. of dry plant. Pie pumpkin gave negative results one time and showed a trace the second time.

Wheat straw and oat straw contained respectively 0.225 mg./Gm. and 0.306 mg./Gm. of dried plant. The amount present in wheat straw and oat straw was probably low because of the manner in which it was dried. The straw had dried slowly in straw piles, thus it was not properly dried.

Table II—Results

Material	Wt. taken grams		Vol. of sol. taken ml.	Reading		Net Reading	Micrograms of Quercetin Equiv.	Quercetin Equiv. mg./Gm. of fresh wt.	Quercetin Equiv. mg./Gm. of dry wt.	Average	
	Fresh	Dry		Borocitric	Citric acid and acetone					Fresh	Dry
Flowers of Helianthus annuus (1)	18.81	4.79	1.0	50	19	31	20	0.106	0.417	0.109	0.429
Flowers of Helianthus annuus (1)	19.48	4.97	1.0	57	23	34	22	0.112	0.442		
Leaves of Helianthus annuus (1)	15.85	4.80	1.0	20	4	16	10.2	0.064	0.213	0.063	0.210
Leaves of Helianthus annuus (1)	15.63	4.72	1.0	19	5	14	9.8	0.062	0.207		
Flowers of Helianthus tuberosus (1)	19.97	4.87	1.0	252	92	160	86	0.430	1.76	0.433	1.77
Flowers of Helianthus tuberosus (1)	19.20	4.68	1.0	254	98	156	84	0.437	1.79		
Flowers of Helianthus tuberosus (1)	22.89	5.57	1.0	311	109	202	107	0.467	1.92	Too far off	
Leaves of Helianthus tuberosus (1)	18.53	4.10	1.0	181	34	147	80	0.431	1.95	0.435	1.97
Leaves of Helianthus tuberosus (1)	19.30	4.27	1.0	193	35	158	85	0.440	1.99		
Leaves of Helianthus tuberosus (1)	20.49	4.53	1.0	162	32	130	70.2	0.342	1.57	Too far off	
Tubers of Helianthus tuberosus (1)	21.36	5.47	1.0	12	6	6	2	Trace	Trace		
Tubers of Helianthus tuberosus (1)	20.07	5.21	1.0	11	6	5	1.5	Trace	Trace		
Root of Rumex (2)	11.17	4.85	0.5	116	96	20	13.6	0.243	0.564	0.241	0.556
Root of Rumex (2)	10.34	4.49	0.5	137	118	19	12.5	0.241	0.556		
Root of Rumex (2)	8.56	3.72	0.5	118	103	15	10.2	0.239	0.548		
Tops of Goldenrod (1)	10.23	4.79	0.1	91	9	82.	47	4.57	9.79	4.63	9.90
Tops of Goldenrod (1)	9.02	4.23	0.1	69	5	64	39.5	4.37	9.34		
Tops of Goldenrod (1)	9.91	4.65	0.1	94	8	86	49.2	4.95	10.58		
Whole plant of Goldenrod (2)	7.79	4.80	0.2	93	10	83	54.2	3.47	5.64	3.67	6.05
Whole plant of Goldenrod (2)	8.36	5.01	0.2	109	12	97	65	3.88	6.47		
Whole plant of Goldenrod (2)	7.65	4.60	0.2	80	8	72	46	3.00	5.00		
Hedgewood (2)	6.85	5.17	1.0	No results							
Hedgewood (2)	5.67	4.29	1.0	No results							
Hedge-apple (2)	12.85	6.79	0.5	56	23	33	21.6	0.336	0.636	Too far off	
Hedge-apple (2)	14.76	7.80	0.5	48	18	30	20	0.271	0.512	0.274	0.519
Hedge-apple (2)	10.63	5.62	0.5	36	13	23	14.8	0.278	0.526		
Hedge-root (2)	13.29	4.24	1.0	94	21	73	47	0.353	1.10	0.362	1.13
Hedge-root (2)	14.12	4.51	0.5	47	9	38	24	0.339	1.06		
Hedge-root (3)	15.66	5.00	0.5	59	10	49	31	0.394	1.24		
Pie-pumpkin (1)	81.54	5.03	1.0	No results							
Pie-pumpkin (3)	87.48	5.40	0.5	15	12	3	Trace				
Wheat straw (1)	—	4.94	1.0	23	1	22	12	—	0.242	—	0.225
Wheat straw (3)	—	4.76	1.0	17	2	15	9.8	—	0.208	.	
Oatstraw (2)	—	4.20	1.0	29	8	21	14	—	0.333	—	0.306
Oatstraw (3)	—	4.22	0.5	14	4	10	5.9	—	0.279		
Flowers of tuberosus (1)	16.73	4.08									
Quercetin		4.2	0.5	149	48	101	56				

(1), (2), (3), refer to the number of the graph that the data was taken from.

53 extractions were made to obtain the above results. The 53 extractions included the

extractions to improve technique and extractions which had various mishaps occur such as an emulsion form in the chloroform layer.

There are now several plants which show presence of quercetin-like substances as a result of this work. Three color qualitative tests were employed to test for quercetin and rutin

Table III

Material in absolute alcohol	Test A. Aqueous Ferric chloride	Test B. Glacial Acetic Acid and magnesium	Test C. Amyl Alcohol Zinc and 15% HCL.
Flowers of tuberosus	Dark olive green color	Slight green color formed	
Leaves of tuberosus	Bluish green color	Very slight reddish color	Very faint red color.
Root of Rumex	Dark olive green color	Yellow color. Anthraquinone derivatives. Probably cover all other colors.	
Hedge-apple	Dark olive green color	Green color formed	
Hedge-root	Olive green color	Green color formed	
Oatstraw	Assumed color of ferric chloride	Colorless	
Goldenrod	Intense olive green color	Reddish-purple color formed	Red color formed
Rutin	Intense olive green color	Reddish-purple color formed	Red color formed

Test A—Rutin gives an intense green color with aqueous or alcoholic ferric chloride[7].
Test B—With glacial acetic acid and metallic magnesium in absolute alcoholic solution at 35 degrees C. a reddish-purple color is formed. Quercetin gives a green color. This test may be used to distinguish rutin from quercetin[10].
Test C—Rutin in amyl alcohol at room temperature is treated with zinc and 15% hydrochloric acid, a red color is formed[9].

Test B shows that goldenrod gives the same kind of a color reaction as rutin. Tuberosus leaves gives a very faint red color which warrants it to be suspected.

Test C substantiated the very similar reaction of goldenrod and rutin. Tuberosus leaves again give a very faint color reaction of the color required.

It is realized that these color reactions do not prove rutin to be present in goldenrod and tuberosus leaves. However, it does very strongly make one suspect that rutin is present in goldenrod.

Estimates of the amount of rutin necessary to meet U. S. requirements run up to a million pounds annually[18]. If this is true, then certainly a source of rutin other than buckwheat is needed. If rutin is present in goldenrod, it might be a new source of rutin. It is well known that goldenrod is a hearty plant and very easy to grow. In this experiment 0.99 per cent was found. These results may be minimum due to the following reasons:

(1) Enzymatic degradation of rutin may have occurred during the period of harvesting and drying of the plants, although precautions were taken to prevent this.
(2) Rutin may have been partially destroyed during the drying process.
(3) The plants may have been harvested at the stage of growth of mini-

mum rutin content. That these factors have an important bearing upon the rutin content of buckwheat has been shown in the detailed studies at the Eastern Regional Research Laboratory[17].

Summary

Several mid-western plants were examined for quercetin-like substances in hopes of finding a new source of rutin. Many of the plants contained quercetin-like substances. Several gave color tests corresponding to the same color reaction given by quercetin. Helianthus tuberosus leaves gave a faint color reaction indicating perhaps a trace of rutin. Goldenrod gave the same type of color reactions as rutin, indicating that goldenrod may be a source of rutin. The amount of this substance found in goldenrod that resembled rutin was 9.9 mg. per gram of dried flowering tops and 6.05 mg. per gram of dried whole plant (portion above ground). This amount may be at its minimum, as the amount may vary at different stages of growth of the plant.

Acknowledgement

I wish to express my appreciation to Mr. R. L. McGregor and Mr. W. H. Horr of the botany department of the University of Kansas for the identification of the plants used in this problem.

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Elasticity, Plasticity, Water Content, and Hardness of Plant Tissues of Different Ages

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I. INTRODUCTION

In an earlier report the author[10] correlated the physical properties of plant tissues with age. Young rhizomes of *Equisetum fluviatile* have a yellowish white color, they are quite plastic and have low breaking stress and low breaking strain. The stress-strain curves are parabolas. The middle age rhizomes have a light brown color, they have higher elasticity, higher breaking stress and higher breaking strain than in youth. The stress-strain curves are S-curves. Old rhizomes have a dark brown color. The stress-strain curves are S-curves which become flatter with increasing old age. Breaking stress and breaking strain decrease with increasing old age.†

To obtain a more thorough knowledge of the physical properties of rhizomes of different ages, observations of the transverse modulus of elasticity, the transverse coefficient of plasticity, and the transverse yield value have been made.

For a full understanding of these age investigations it is important to know that Young's modulus of cylindrical plant tissues increases with increasing hardness[10]. By studying cross sections of different cylindrical plant tissues it was found that a soft tissue has a small Young's modulus and that a heavily built up or hard tissue has a large Young's modulus.

In order to get accurate results, hardness measurements for a certain volume of rhizomes of different age were made. These results were obtained by drying the plant material. Besides this drying proved that loss of water and aging of plant material are related.

The relation of the water content in a plant tissue to other plant properties has to be investigated. Such investigations have been done for arteries.

Living tissues behave as nonliving colloids under influence of age. A newly formed colloidal gel is characterized by maximal capacity to bind water. With reduction of the portion of water comes a decrease in the extensibility of the colloid. Arteries owe their chief characteristic, elas-

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†Rhizomes mentioned in this paper are rhizomes of *Equisetum fluviatile.*

ticity, to the presence of an elastic colloid[15]. An artery behaves much the same as a rubber tube. The aging rubber tube progressively loses extensibility. At last it is granular and cracked. The aging rubber tube is found to become harder. The same happens in an old, sclerotic artery. The arterial behavior is a matter of colloidal properties of elastic tissues. The alterations of colloids (arteries and protoplasm) through age are characterized by decrease of extensibility of colloids (arteries and protoplasm). With decrease in extensibility the protoplasm becomes less hydrated. Aging of protoplasm is a process of dehydration. In human cartilage there is a progressive decrease in water content up to the fourth decennium. With age the cartilage shows an increase in cholesterol and calcium, exactly as does the arterial wall. The characteristic tendency to infiltration of calcium and lipoids into aging arteries is a general property of certain colloidal structures. The loss in water is the primary process. There is a decreased capacity to hold water in solution. The least soluble plasma constituents cholesterol and calcium are first deposited. Consideration of the physicochemical properties of arteries lends support to the view that arteriosclerosis (produced by aging) depends on changes in the elastic tissue. These changes reduce the resiliency of the elastic tissue, and lead to arterial dilatation. In the case of arteriosclerosis there is a progressive decrease in the nutrition of portions of the arteries. Deposition of lipoids and calcium in such devitalized areas are the usual events. With loss of the degree of tissue hydration of youth come changes in the colloids of the artery walls so that they less successfully hold in solution substances infiltrating the plasm. These substances are calcium salts and cholesterol.

Now we have to expect that the water content of a plant tissue, like of an artery is related to aging. We have to investigate the water content of a certain volume of *Equisetum fluviatile* rhizomes in different ages.

II. METHOD AND RESULTS

1. Measurement of Elasticity and Plasticity

The methods and equipment for measuring elasticity and plasticity were the same as those reported earlier[12]. The plant material used was the rhizome of *Equisetum fluviatile.*

Stress-strain curves in length direction were first investigated. Young, middle age, and old age rhizomes were used. Stress-strain curves are parabolas, and S- curves. Measurement results are reported in table I. Inspections of curves and of this table show that for young rhizomes Young's modulus, breaking stress and breaking strain are all low. Hence young rhizomes are soft and slightly elastic. The middle age rhizome has a high Young's modulus, and high breaking stress and breaking strain. These rhizomes are hard and elastic. The old age rhizomes

Table I

	Longitudinal Direction			Transverse Direction			
	Young's modulus	Breaking stress	Breaking strain	Modulus of elasticity	Ratio of mod. of elast.	Yield value	Coefficient of plast.
Substance	dynes/cm^2	dynes/cm^2		dynes/cm^2	Longit./transv.	g/cm^2	cm^2/g
young rhizomes	2×10^8	27.0×10^6	0.259	0.62×10^8	3.2	66.8×10^2	4.5×10^{-6}
middle age rhizomes	5×10^8 (4×10^8)	72.3×10^6	0.393	1.43×10^8 ($1.\ 1\times10^8$)	3.5 (4)	121×10^2 (77×10^2)	2.3×10^{-6} (2.0×10^{-6})
old rhizomes	6×10^8	70.4×10^6	0.360	0.96×10^8	6.2	77×10^2	$2\ 1\times10^{-6}$

have a very high Young's modulus. Breaking stress and breaking strain are slightly less than the values for middle age rhizomes. Hence, old age rhizomes are fairly rigid.

In all these foregoing cases the rhizomes of *Equisetum fluviatile* show rubber-like elasticity. Young's modulus of rhizomes of different age increases with increasing age.

Force-deflection curves in transverse direction of rhizomes of different age (Fig.1) were investigated[12]. For getting these new curves a load

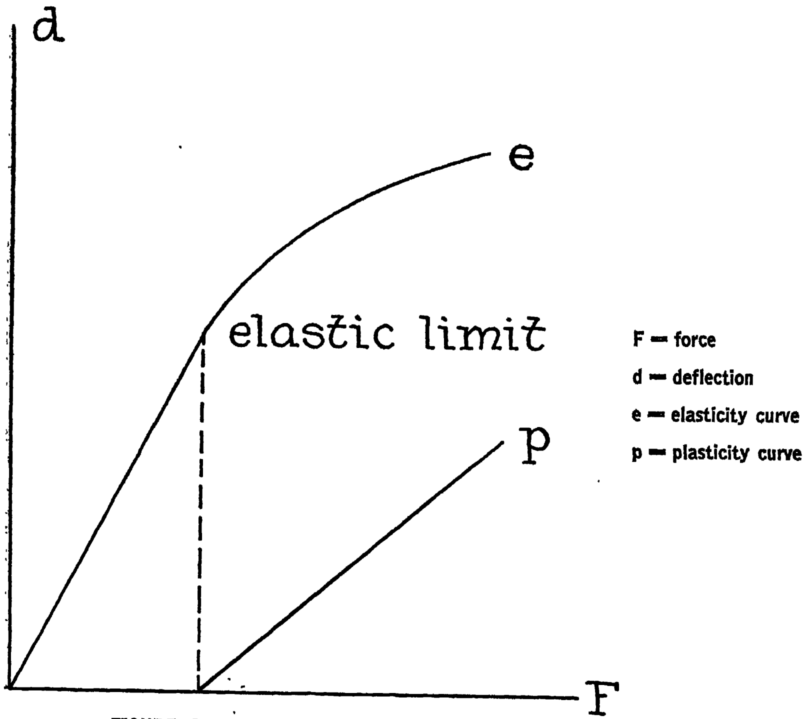

FIGURE I Force - Deflection Curve of a Cylindrical Plant Tissue

of 500 g in length direction was applied. The force-deflection curves are composed of ascending elasticity curves and straight line plasticity curves in the (F, d) system. For young rhizomes in transverse direction there were observed a yield value, a coefficient of plasticity (see table I), a transverse modulus of elasticity of 0.62x10^5 g/cm^2 and a ratio of moduli of elasticity in length and transverse direction of

$$\frac{2 \times 10^8}{0.62 \times 10^8} = 3.2.$$

Because of the small ratio of the moduli of elasticity, young rhizomes of *Equisetum fluviatile* are slightly anisotropic. They are a little harder in length direction than in transverse direction. The high coefficient of plasticity in transverse direction 4.5x10^{-6} cm^2/g shows that young growing rhizomes of soft material are quite plastic.

For middle aged rhizomes in transverse direction were observed a yield value, a coefficient of plasticity (see table I), a transverse modulus of elasticity of 1.43x10^5 g/cm^2, and a ratio of moduli of elasticity in length and transverse direction of

$$\frac{5 \times 10^8}{1.43 \times 10^8} = 3.5.$$

Hence, middle aged rhizomes are more anisotropic than young rhizomes. They are harder in length direction than in transverse direction because hardness increases with increasing modulus of elasticity. The relatively small coefficient of plasticity in transverse direction 2.3x10^{-6} cm^2/g shows that rhizomes of middle age are not very plastic.

For old age rhizomes in transverse direction were observed a yield value, a coefficient of plasticity (see table I), a transverse modulus of elasticity of 0.96x10^5 g/cm^2, and a ratio of moduli of elasticity in length and transverse direction of

$$\frac{6 \times 10^8}{0.96 \times 10^8} = 6.2.$$

Hence, old age rhizomes are much more anisotropic than young and middle aged ones. They are also much harder in length direction than in transverse direction. Rigidity in length direction is great during old age. The small coefficient of plasticity in transverse direction 2.1x10^{-6} cm^2/g (a little less than for middle aged rhizomes) shows that old age material is not very plastic.

The yield value in transverse direction is related to the elastic limit in transverse direction. The small yield value of 66.8x10^2 g/cm^2 for young rhizomes is reasonable because the material is plastic.

The high yield value of 121x10^2 g/cm^2 of middle aged rhizomes

is reasonable because of the great strength (great hardness) of the material.

The small yield value of 77×10^2 g/cm^2 for old rhizomes is reasonable because of many weak spots in old material and because of deterioration of old rhizomes.

2. Water Content and Age of Plant Tissues

The apparatus used for obtaining the water content in rhizomes of different ages was composed of a transparent, hollow lucite prism and a metal piston. At the bottom of the prism a pile of cylindrical pieces of rhizomes of a certain age was placed. The length of the pile was 3 cm. By drying of the plant material in air and in an electric oven for 4 days the water content of the plant pile was measured. The result which was obtained in one of the measurements is shown in table II.

Table II

	% water	% dry substance
Young plant pile	70.4	29.6
Middle age plant pile	55.2	44.8
Old age plant pile	29.7	70.3

This measurement and similar measurements show that the water content of a certain volume of rhizomes decreases with increasing age. The rhizomes which were used in the beginning were dryed for 24 hours. The fresh plant material was taken from the sandy bottom of the lake shore water.

3. Measurement of Hardness in Different Ages

According to Record[8] the term hardness is used in two senses, namely: Firstly resistance to indentation, secondly resistance to abrasion or scratching.

In the following experiments hardness is defined as resistance to indentation. Tests for indentation were made by penetration of a dry plant pile of 3 cm length in the lucite prism with the metal piston. The penetration was done by using a weight of 1000 g. This weight was put on the platform at the top of the piston. It is assumed that the plant material was practically dry after drying for three days.

By using weight 1000 g on the platform there were obtained:

Impression 0.8 cm in a dry, young rhizome pile of *Equisetum fluviatile,* hence hardness k/0.8.

Impression 0.5 cm in a dry, middle age rhizome pile of *Equisetum fluviatile,* hence hardness k/0.5.

Impression 0.3 cm in a dry, old age rhizome pile of *Equisetum fluviatile,* hence hardness k/0.3.

By II,1 there is Young's modulus of young rhizomes 2×10^8 dynes/cm², Young's modulus of middle age rhizomes 5×10^8 dynes/cm², and Young's modulus of old age rhizomes 6×10^8 dynes/cm². Hence Young's modulus increases with increasing age.

Now the simplest assumption about relation of hardness and Young's modulus for different ages is: Hardness is proportional to Young's modulus.

Then it is

$$\frac{0.8}{k} : \frac{k}{0.5} : \frac{k}{0.3} = 2\times10^8 : 5\times10^8 : 6\times10^8$$

$$1.25 : 2 : 3.3 = 2 : 5 : 6, \quad \text{or}$$

$$2.5 : 4 : 6.6 = 2 : 5 : 6.$$

The proportion is approximately correct. Other measurements gave similar results. Hence it is to be concluded:

During different ages for *Equisetum fluviatile* rhizomes there is hardness proportional to the logitudinal Young's modulus. The values of hardness in this paragraph are average values.

4. Measurement of Hardness for Cylindrical Plant Tissues

For getting a general law about the relation of hardness and elasticity in plant tissues cylindrical tissues of *Equisetum fluviatile* rhizomes, *Brasenia schreberi* stems, and *Rhus glabra* roots were investigated.

It is assumed that the plant material was practically dry after drying for 3 days. Experiments for impression were made by penetration of a dry plant pile of 3 cm length in the lucite prism with the metal piston loaded by the weight of 1000 g.

Impression 0.4 cm in a dry, middle age pile of *Equisetum fluviatile* rhizomes, hence hardness $k/0.4=2.5k$.

Impression 0.35 cm in a dry, middle age pile of *Brasenia schreberi* stems, hence hardness $k/0.35=2.9\ k$.

Impression 0.1 cm in a dry, middle age pile of *Rhus glabra* roots, hence hardness $k/0.1=10\ k$.

A simple assumption about relation of hardness and specific gravity for cylindrical plant tissues is: Hardness is proportional to specific gravity. Here specific gravity is defined as quotient of weight of dry tissue and of volume of fresh tissue.

For middle age *Equisetum fluviatile* rhizomes specific gravity is 0.22[11]

For middle age *Brasenia schreberi* stems specific gravity is 0.34.

For middle age *Rhus glabra* roots specific gravity is 0.48.

Then it is

$$k\cdot2.5 : k\cdot2.9 : k\cdot10 = 0.22 : 0.34 : 0.48, \text{ or}$$

$$25k : 29k : 100k = 22 : 34 : 48.$$

The proportion is approximately correct. Hence it is to be concluded: During middle age for a certain volume of cylindrical plant tissues there is hardness proportional to specific gravity. Because specific gravity increases with increasing Young's modulus[11] there increases during middle age for a certain volume of cylindrical plant tissues hardness with increasing Young's modulus.

By using II,3 we find the general law: For a certain volume of cylindrical plant tissues in different ages there increases hardness with increasing Young's modulus.

III. DISCUSSION

1. Physical Properties of Equisetum fluviatile Rhizomes of Different Ages

My previous work [12, 13, 14] led to the following conclusions: The greater the ratio between the moduli of elasticity for cylindrical plant tissues, the greater is the ratio between the amounts of crystalline and amorphous cellulose in the average secondary cell wall (parallel to the axis), the greater the percentage of cellulose in this wall, and the greater the orientation of cellulose molecules parallel to the axis of the tissue in this wall.

The ratio of the moduli of elasticity for young rhizomes of *Equisetum fluviatile* has the small value 3.2. Hence the ratio of the amounts of crystalline and amorphous cellulose in the average secondary cell wall is small, the percentage of cellulose in this wall is small and the cellulose molecules deviate much from the axis of the tissue.

The ratio of the moduli of elasticity for middle aged rhizomes of *Equisetum fluviatile* has the middle value 3.5. Hence, the percentage of cellulose in the average secondary cell wall is greater in middle aged rhizomes than in young rhizomes. The average cellulose molecules deviate less from the axis than in young rhizomes.

The ratio of the moduli of elasticity for old rhizomes of *Equisetum fluviatile* has the great value 6.2. Hence the ratio of the amounts of crystalline and amorphous cellulose in the average secondary cell wall is great, the percentage of cellulose in this wall is great, and the average cellulose molecules do not deviate much from the axis of the tissue.

In all ages the amount of amorphous cellulose is greater than the amount of crystalline cellulose because rhizomes of *Equisetum fluviatile* are rubber-like elastic[12].

In youth the average secondary cell wall contains much amorphous and little crystalline cellulose. In old age this wall contains less amorphous cellulose than in youth and much crystalline cellulose.

Aging causes old tissue to become less isotropic than youthful tissue.

The increase in the amount of crystaline material in *Equisetum*

fluviatile rhizomes with aging results in increased Young's modulus and increased hardness of these tissues.

There are some mechanical properties of secondary cell walls of *Equisetum fluviatile* rhizomes which change with age.

(a) The percentage of cellulose in young secondary cell walls is small and is great in old secondary cell walls. The young secondary cell walls become thicker with age by apposition of cellulose.

(b) Secondary cell walls contain crystalline and amorphous cellulose. Young walls contain much amorphous cellulose, they are soft, old walls contain much crystalline cellulose, they are hard.

(c) The cellulose molecules in average secondary cell walls of old rhizomes are more parallel to the rhizome axis than the cellulose molecules in young average secondary cell walls.

2. Chemical Properties of Equisetum fluviatile Rhizomes of Different Ages

Glucose rings probably pass from protoplasm to the cell walls of higher plants. Thus the cellulose of the cell wall might be formed[12].

There is a general conclusion that youthful plant tissue has a greater oxidizing capacity than senescent tissue. Hence young rhizomes are more influenced by oxygen than old rhizomes.

According to Goddard and Goodwin[2] oxidation of dead cells and of living cells is possible. Respiration is enzymatic oxidation of living cells. So oxidation of rhizomes may be enzymatic (respiration) or non-enzymatic.

3. Protoplasm in Cells of Equisetum fluviatile Rhizomes of Different Ages

Because of continuity of properties of cell walls and protoplasm there is a close relationship between protoplasm and cell walls during the different ages of rhizomes. The process of aging probably takes place in the molecules of plants. The elementary process of elastic extension and contraction of plant tissues is a molecular or micellar phenomenon. It might, therefore, be assumed that in general the physical changes in aging of plants are closely related to elasticity and plasticity. According to Seifriz [9] one of the most important physical properties of protoplasm is elasticity. It is reasonable to assume that aging of protoplasm shows a correlation with elasticity. This assumption is supported by a remark to Seifriz[9] one of the most important physical properties of protoplasm exhibits very little elasticity and is plastic. As it ages, elasticity increases, and plasticity becomes correspondingly less.

4. Submicroscopic Structure of Equisetum fluviatile Rhizomes of Different Ages

For getting a general law with respect to elasticity and submicroscopic

structure of rhizomes of different ages table I is used. This table contains the values for the elastic and the plastic behavior of rhizomes of different

In table I the values for middle age rhizomes in parentheses were found in 1945. This coincidence of values proves that the material investigated of rhizomes is rather homogeneous. The plant material nearly is of a pure line. This is reasonable because all rhizomes were found at Marl Bay, Douglas Lake, Michigan, and in many cases pieces of the same rhizome were investigated. Besides the rhizomes at Marl Bay look very healthy. Therefore, here aging might be physiological and not pathological. There is pathological aging if there is a premature breakdown owing to disease of the plant tissue. There is physiological aging if there is a natural breakdown of the plant tissue.

For cylindrical plant tissues it is reasonable to conclude that the higher the value E of Young's modulus in length direction, the higher is the modulus of elasticity μ in transverse direction and the smaller is the coefficient of plasticity Φ. Hence there is the equation

$$E = m \cdot \frac{\mu}{\Phi}, \text{ where}$$

m is a constant, or

$$\frac{E}{\mu} \cdot \Phi = m.$$

By using the values of table I we find

for young rhizomes $\quad : \frac{E}{\mu} \cdot \Phi = 3.2 \times 0.0000045 \text{ cm}^2/\text{g} = 0.00001 \text{ cm}^2/\text{g},$

for middle age rhizomes $\quad : \frac{E}{\mu} \cdot \Phi = 3.5 \times 0.0000023 \text{ cm}^2/\text{g} = 0.00001 \text{ cm}^2/\text{g},$

for old age rhizomes $\quad : \frac{E}{\mu} \cdot \Phi = 6.2 \times 0.0000021 \text{ cm}^2/\text{g} = 0.00001 \text{ cm}^2/\text{g}.$

For all these rhizomes is $m = 0.00001 \text{ cm}^2/\text{g}$ and

$$E = 0.00001 \cdot \frac{\mu}{\Phi} \text{ cm}^2/\text{g}.$$

The elementary process of elastic and plastic expansion takes place in molecular or micellar dimensions. Hence this equation suggests that there is a similar submicroscopic structure in cell walls of rhizomes of different age.

Generally for rubber-like elastic cylindrical plant tissues[12] is

$$E = 0.000015 \cdot \frac{\mu}{\Phi} \text{ cm}^2/\text{g}.$$

Hence there is a similar submicroscopic structure in cell walls of rubber-like elastic cylindrical plant tissues.

For the rhizomes of different age we have

$$\frac{E}{\mu}\cdot\Phi = 0.00001 \text{ cm}^2/\text{g, or}$$

ratio of moduli of elasticity x coefficient of plasticity = 0.00001 cm^2/g. That means the greater the elasticity or the crystallization of the rhizome is, the smaller is the plasticity of the rhizome. Crystallisation is probably related to death and plasticity to life. According to our equation $\frac{E}{\mu}$ (crystallisation) is small for young rhizomes and Φ (plasticity is great. $\frac{E}{\mu}$ (crystallisation) is great for old rhizomes and Φ (plasticity) is small. Therefore young rhizomes have many living cells and old rhizomes have many dead cells.

5. Aging of Equisetum fluviatile Rhizomes

We found some properties of *Equisetum fluviatile* rhizomes which change with aging. The results obtained are as follows:

(a) For rhizomes breaking stress and breaking train are decreasing with increasing old age (introduction).

(b) The water content of a certain volume of rhizomes decreases with increasing age (II, 2).

(c) During different ages for rhizomes there is hardness proportional to the longitudinal Young's modulus (II, 3). Therefore hardness increases with increasing age, because Young's modulus increases with increasing age.

(d) The rhizomes contain much amorphous cellulose in youth and much crystalline cellulose in old age (III, 1).

(e) Aging causes that old rhizomes are less isotropic than young rhizomes (III, 1).

(f) Young rhizomes have a greater oxidizing capacity than old rhizomes (III, 2).

(g) Protoplasm when young exhibits very little elasticity and is plastic. As it ages elasticity increases and plasticity becomes correspondingly less (III, 3).

(h) For rhizomes of different age there is validity of the equation ratio of mod. of elast. x transv. coeff. of plast. = 0.00001 cm^2/g (III, 4). The ratio of moduli of elasticity is great for old rhizomes and small for

young rhizomes. The transverse coefficient of plasticity is great for young rhizomes and small for old rhizomes.

(i) According to Wells[15] living tissues behave as non-living colloids under influence of age. Since very early times aging has been associated with withering. A newly formed colloidal gel is characterized by maximal capacity to bind water. As it ages the colloid has a reduced capacity to hold water. The same result was found for *Equisetum fluviatile* rhizomes of different age. By II, 2 the water content of the young pile of rhizomes was 70.4%, the water content of the middle age pile was 55.2%, and the water content of the old age pile was 29.7%. Hence the water content of a young rhizome decreases with aging.

According to Heilbrunn[4] in rats, during the first year of life the water content continues to decrease and there is to be observed an increase in percentage of dry substance.

Thus both plant tissues and mammals lose water with increasing age. The living organism of animals has no means of getting rid of insoluble, probably crystalline materials which may be deposited within its cells because of loss of water. So loss of water may be an important factor in the aging process of living tissues. This result is supported by Lansing[7] who found that calcium increases with age in plants. Deposits of calcium oxalate and carbonate increase with age. There is a general law in nature that living tissues and non-living colloids loose water with aging.

By III, 2 there is a general conclusion that youthful plant tissues consume more oxygen than old tissues. We will find that the same law is correct for aging rubber.

Vulcanized rubber rods are oxidized in a dark room[11]. At last they are deteriorated and aged. The stress-strain curves of these rods have the same shape as stress-strain curves of *Equisetum fluviatile* rhizomes of different age (introduction). Hence we conclude that rhizomes may consume decreasing quantities of oxygen with increasing age. In these rhizomes respiration and oxidation take place (III, 2).

According to the most general law for physiological aging of *Equisetum fluviatile* rhizomes these rhizomes loose water with aging, unstable compounds may be formed and oxygen may be consumed by the aging rhizomes.

Guth[8] writes about rubber: "Rubber belongs to a class of substances which nature uses as a framework for all living things. The similarity between rubber and resting muscle has long been recognized. Of course, the behavior of muscle is in general much more complicated than that of rubber. Nevertheless, in certain essential aspects rubber may

be considered as a simple prototype or model of muscle." In the same way rubber may be considered as a simple prototype of rhizomes of *Equisetum fluviatile.* So it is to be concluded that *Equisetum fluviatile* rhizomes behave with respect to aging by oxidation like rubber.

Two other examples for decreasing consumption of oxygen with increasing age may be mentioned:

In 1934 Kidd[6] made a very thorough study of the stages of the development of the apple fruit. He found a relation for decreasing respiration in the different stages of development of this fruit. Death of the fruit occurs when respiration ceases.

According to A. E. Cohn[4] it was found that as animals (dogs) grew older their hearts, per gram of heart muscle, consumed less oxygen to a significant degree, even when correction was made for disturbing factors, such as that larger hearts consume less oxygen per unit of weight and that the consumption of oxygen per gram of heart decreases with the slower rates of older hearts. But when, as has just been said, these corrections are made, the decrease in consumption of oxygen with age remains significant.

Besides the result that respiration produces aging is supported by Pfeffer's discovery (1900) that growth of plants depends on energy derived from respiration.

The importance of water content and respiration for aging in plant tissues is supported by Henderson's[5] investigation (1934). According to him it is shown that there is a close relation between the rate of absorption of water by maize seedlings and the rate of respiration of their roots.

IV. SUMMARY

1. The water content of a young *Equisetum fluviatile* rhizome decreases with aging.
2. Hardness of the rhizomes increases with aging.
3. Young rhizomes are little elastic and very plastic, old rhizomes are very elastic and little plastic (see table I).
4. A young rhizome is nearly isotropic. Aging causes it to become anisotropic.
5. A similar submicroscopic structure is in cell walls of rhizomes of *Equisetum fluviatile* of different age because of the same elasticity-plasticity equation for these tissues.
6. Living tissues and non-living colloids loose water with aging (physics of aging). Living tissues and non-living colloids consume less oxygen in old age than in youth (chemistry of aging).
7. According to the most general law for physiological aging of rhizomes

these rhizomes loose water with aging and besides aging is caused by respiration and oxidation of the rhizomes.

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Preliminary Report On An Experimental Project In Supervision In Clinical Psychology (A. Psychotherapy)*

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In order to provide a learning experience in psychotherapy for clinical psychology trainees, the experimental project to be described was set up to develop methods of supervision applicable in a hospital setting in cooperation with the VA and the affiliated university. The authors will attempt to describe the supervisory philosophy against the background of a specific training structure and with the help of a case demonstration.

Supervision is no recent human invention. The oldest human documents bear testimony to the fact that the function of supervision has been known to man since the beginnings of civilization. The story of Joseph in Genesis seems ample biblical proof that then as now supervisors were needed but that the job was not a desired one since quite frequently it invited the wrath of the administrator and the supervisee. Present day administrators may have different reasons to get rid of supervisors than did Potiphar, but all these reasons then and now can be reduced to lack of supervisory skill in the handling of interpersonal problems, just as Potiphar's wife did testify. The overseer of Potiphar's household, Joseph, was demoted to be the overseer of all the prisoners entrusted to him by the new administrator, the keeper of the prison. He oversaw their work in the quarry and we must assume that he evaluated their progress. Joseph was charged with the resposibility of ministering unto the Pharaoh's chief butler and chief baker. So skillful must Joseph have been in their supervision that he evaluated them correctly. We might assume that his interpretation of their dreams indicated his awareness of the baker's inability to reform, and the butler's genuine desire for redemption. The chief butler was restored to butlership again while the chief baker—having failed the test of the evaluation—was hanged, as Joseph had so authoritatively indicated in his dream interpretation to them.

Joseph's supervisory skill was rewarded and he was made Pharaoh's chief administrator. Thus it appears that the desire for professional advancement existed way back in the ancient past, and is not merely a function of our modern, competitive and individualistic Western society.

The crude methods of supervision known to the ancient Pyramid

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builders—their brutal enforcement of the proper submissive attitude, of proper working habits of those entrusted to them—have given way to a more civilized way, but the underlying emotional problems that arise between the administrators, the supervisors and the supervisees are very much the same as we will find out if we listen with a sensitive ear to the emotional melody—at times harmonious, at times a discord—of the supervisory process.

Supervision of clinical psychologists in training is not only the enforcement of work. The professional supervisor is more than the overseer of the ancient quarry, or the modern conveyor belt. He is, of course, responsible for seeing that the work is done; he evaluates the work and aids the supervisee. But he is responsible also for the supervisee's professional development. He carries the function of the overseer and teacher at the same time, he is therefore responsible to the administration of the hospital or clinic and the training school as well.

In teaching the skills of the clinical psychologist, practical purposeful work with human beings in a living situation is necessary. The supervisor, therefore, cannot conceive of his teaching function as theoretical textbook teaching. He teaches "doing" and will do this best by "doing". His method must be a psychological one and will make use, therefore, of the interpersonal relationship between learner and teacher.

But more than that, he and the supervisee do not work in a social vacuum. They work within the framework of the clinical setting and both have professional responsibilities to each other, to school and hospital, and last and most to the patient who comes to them for help with his problems.

The structure of this situation will find its psychological reflection in the supervisory relationship and must be taken into account when developing supervisory skill and initiating rules and procedures which guide the supervisor and the learner.

The structure of the psychotherapy training program to be described was developed in relation to an existing hospital setting. It was not arbitrarily devised but arranged in such a way as to fit most easily into present hospital reality.

The psychology interns are assigned to specific hospital services and are administratively responsible to the service chief, a staff psychiatrist. Their functions include diagnostic testing and participation in many ward activities in cooperation with the other professions. The service chief was asked to select suitable cases for their psychotherapeutic work which was supervised by a consultant supervisor (one of the authors). Supervisor and supervisee were made responsible to a Psychotherapy Council under the leadership of the Chief of Psychological Service (also one

of the authors). The Psychotherapy Council was not only responsible for final review of the students' work and their suitability for further training, but also for various policies to be worked out in conjunction with the service chiefs. The Council, thus, was the administrative link between training and service organizations. While this structure was developed for psychotherapy training, the authors wish to stress its applicability to other aspects of training* which they hope to describe in a future paper.

The consultant supervisor started the supervision of four clinical psychologists who were assigned patients by the chief of their service. Weekly supervisory conference hours were held with each trainee. The supervisees were responsible for process recording of their psychotherapeutic interviews and were required to submit the material in advance. This clinical material was then used as the basis for discussion. The focus of the supervisory conference was not on the patient's dynamics but on the supervisor and on his efforts to help the patient more effectively.† While both supervisor and supervisee were allowed creative freedom in the way they used the supervisory conference, they were limited by the structure of the situation which defined their responsibilities and their different functions.

The use of this professional structure, its helpfulness, can best be demonstrated by the description of the task of "mutual evaluation" which was the professional responsibility of both supervisor and supervisee after the initial learning period of six months had expired.

The students were told that there would be a mutual evaluation at the end of the learning period. They were required to choose two interviews, an early one and a late one, selected to show their early problems in carrying on psychotherapy, their progress, and the present state of their skill. Both supervisor and students would study the material independently, would write evaluations of their work, and would discuss this together in a final evaluation conference. A final summary (for which both would be responsible) together with the other material would

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*Clinical psychologists in this program are trained in diagnostic and therapeutic work, research in clinical problems, and in the acquisition of skills in teaching and supervision.

†The psychotherapeutic philosophy of the consultant supervisor is based on psychoanalysis. His specific application of psychoanalytic thinking to problems of teaching and supervision has been described in: "Dynamic Aspects of the Teaching of Psychology", *Bulletin of the Menninger Clinic*, Vol. 12, No. 3, May 1948, pages 90-95; "An Illustration of the Supervisory Learning Process" (unpublished). The second author, while not rejecting the psychoanalytic theory of personality, has practiced and contributed to the literature of nondirective therapy. (Sargent, Helen: "Nondirective Treatment of a Conditional Motor Block", *Journal of Abnormal and Social Psychology*, Vol. 42, No. 2, April 1947, pages 243-252, and other articles.) It is interesting that in spite of certain ideological and technical differences in regard to content taught, both find a common ground in the structural dynamics of mutual evaluation and a joint enthusiasm for structure which creates a situation in which the learner can grow and achieve mature self-evaluation.

be submitted to the Psychotherapy Council, including the evaluation and recommendations for future training or its discontinuance.

The Psychotherapy Council, consisting of the Chief of Psychological Service, four psychiatrists, the consultant supervisor and the service chiefs, was organized for the purpose of studying the material and using it for final decisions in regard to the supervisees.

The following is a sample illustration* of this work. It reflects not only the supervisory relationship, but also the specific value which accrued from the structure of mutual evaluation (the agreement and disagreement of the independently written evaluations), and the change in therapeutic technique as reflected in the two sample interviews. The material will also indicate the learning problems the supervisee faced. It consists of the evaluation written by the supervisor, the therapist's own evaluation, the beginning interview, a later interview (either at the end or towards the end of the learning experience) and finally, the final summary of the evaluation conference with recommendations to the Psychotherapy Council. Attention is called once more to the fact that the supervisor's and the therapist's evaluations had been written independently and that both saw these evaluations for the first time during the final conference. The reader will be interested in studying the amount of agreement in these evaluations which can be considered as an indication of the nature of the supervisor-supervisee relationship within the learning situation. It will also be noted that in the psychotherapeutic interviews, responses of the psychotherapist are printed in italics in order to emphasize the responses of the psychotherapist and in order to demonstrate more clearly the change that has taken place in him. The material in italics can be considered as projective material and can be interpreted in terms of the change in attitude that has taken place in the therapist as he works with the patient.

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August 18, 1948

Mr. H. began the hour by telling what occurred in psychodrama the preceding hour. He felt it was an important session and that it brought back to him something he had not thought of since childhood. The drama somehow got on the subject of knives and from there to the telling of castration threats and fears. Mr. H. then remembered the following incident which he told to the group and which he repeated to me.

He thinks he must have been three or four years old at the time. He was doing a lot of thumb-sucking at the time. His mother tried all sorts of methods to break him of it like tying his hands and putting axle grease on his thumbs. In desperation she asked an "ugly, big Indian" hired man what to do about it. He promised to break him of the habit. He threatened to cut off the boy's ears, his nose, his thumb. "When my mother wasn't around, he also said he

*The supervisee has given us permision to use this material. It has been disguised for reasons of professional ethics but as far as possible is an accurate representation of the actual work.

would cut off my penis." The patient would run screaming to his mother, the Indian following, pretending he was going to cut off his ears.

I said something I shouldn't have (I've repressed it now.) Anyway, it got him off the subject and he started telling of another visit from his sister. He was in the photography shop when they arrived, trimming some pictures. It annoyed him that they came and he showed his annoyance by finishing the job before going to see them. He said the visit started out well enough but that he got upset when he heard that the brother-in-law was trying to get a job here at the hospital. He would prefer not to have them around. He was also upset by the fact that they talked so lightly of the brother-in-law's frequent job-changing. It made him think of his own difficulty in holding a job and he felt it was not a joking matter. He was very happy that they did not stay long and hopes there will be no job here for the brother-in-law. He also resents that they want *him* to hold the baby, to goo and smile at him. "I have enough trouble smiling anyway without making a damn fuss over a kid."

I tried to get him back to the castration story, asking whether anything else occurred to him concerning it. He couldn't remember anything but said that he had terrible fears as a kid and that he still has. As a child he was afraid of the dark, afraid to sleep alone. While in high school he still had deathly fears when alone after dark. Just before he went in the army he was terribly afraid to go to the chicken house after dark. He told how his father publicly made fun of him for being so afraid. He also told how at times he would run to his parents' bedroom to get in bed with them. He would always get between his parents saying he felt safer with one on each side of him. *I asked what else was accomplished by that.* He responded immediately, "It also kept them apart."

He says he doesn't know what he feared—maybe that someone would kidnap or hurt him. "Now I wonder if it all started with the fear that someone might come and cut off my penis." He then recalled an incident when he was sleeping with his brother. His brother had been out late; Mr. H., alone and afraid, had been trying to stay awake until his brother arrived. But he dozed off, wakened in a cold sweat when someone had thrown his arm over him and "started going to work on me." He hurried on to say that although his brother often did that, he still wasn't sure it was his brother. He felt his arm "but it didn't feel like my brother's." *I questioned the "going to work"* and he explained "like he was screwing me." "I can't remember but I wonder if I used to play around with him. I can't remember doing it but maybe I even used to get my mouth down on it." He has always shied away from talk about his brother. *His way of telling this incident makes me think* that he has had homosexual relations with his brother which he remembers clearly but cannot bring himself to tell them.

He then told of his trumpet playing in the school band but "didn't blow" the trumpet at all. He would hold it to his mouth, pretending to play it "but I didn't blow it." After a while he smiled and said, "I was just thinking about the way I said that—about not 'blowing' the trumpet." *I smiled with him and said that I had thought about it too. I pointed out that he had also stopped singing, that he had been forced to stop thumb-sucking, that everything that used the mouth, he felt he had to stop. "Do you feel there's something bad about the mouth?"* He related how he had been told that thumb-sucking would affect his health, would deform his face, might even drive him crazy. *I remarked that still a strong desire to use the mouth continued and wondered why he thought that might be.* He didn't know and *I couldn't keep quiet and so asked*: *"When did you first use your mouth?"* The answer came rather quickly, "When I sucked my mother's breast." He added, "You know, I sometimes think I can remember sucking her breast—I just seem to get a picture of lying on her lap and her having one breast out and me sucking it." *So then I didn't know what to say.* He went on to tell how even the thought of thumb-sucking made him think of taking a penis in his mouth—that the word suck bothered him. *I said that it bothered a lot of people, that many mothers were upset over their children's thumb-sucking for that reason; also, that's why the word is included on the test he had some time ago.* He said, "I probably said 'dick' to that." *I had the test folder, checked and assured him that he had not.* He seemed relieved that being bothered by the word "suck" was not something peculiar to him.

Mr. H. used the last few minutes of the hour to run himself down, saying he wasn't very smart. This stemmed from the above reference to the tests. He remembered missing some easy arithmetic problems.

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August 18, 1948

Mr. H. wore his worried look when he arrived today and he immediately began to demonstrate verbally that he was disturbed. He said he was very upset and confused. He thought much of the disturbance was due to the psychodrama session of the previous hour. Last time it bothered him that no one praised the way in which he played his role. This time he felt neglected because his role hadn't been discussed at all. He jumped from one topic to another, however, *suggesting to me* that it was not really the psychodrama that was bothering him. He said that he seemed more confused, that his head was hurting more this week. *I thought he had gained some insight into the problem his mother has posed for him during the last two sessions. If he had, now I felt he was trying to shut out all understanding.* When he asked, "Can't we try hypnosis—I think it might help clear things up more quickly."

B. *"This has become pretty painful and you feel hypnosis might return us to a pleasant, painless situation."*

H. "I just want it to move faster." There was a pause, followed by "I asked Dr. O'S this morning if I could have an hour with him—I think that might help speed things up."

B. *"You've really gotten angry with me, haven't you?"*

H. Well, we didn't accomplish anything last session, and we don't seem to be getting anywhere now. I guess I should be angry at myself. It's my fault I'm not getting anywhere. Maybe there's something else sticking that should come out."

There was a long pause during which Mr. H. fidgeted, was very uncomfortable. His stomach was growling loudly. He smiled and commented on the noise it was making. *I had to laugh.* Mr. H. became angrier, saying, "Go ahead and laugh. It's not funny to me."

B. *"I laughed because I thought you knew why it was growling and that it amused you too."*

He continued to look sour and un-amused. Nothing was said for a few minutes. Mr. H. rather exploded with, "Now you're trying to torture me again."

I guess he must have gotten me angry now. I didn't recognize it at the time I said it. But his reaction and my later reflection on it showed how aggressive my next comment was. The sarcasm must have been obvious when I said, "Would you like us to talk about your plans for the weekend?" Mr. H. really exploded: "I don't want to talk about any Goddam plans for anything. I might as well leave—I can't think of anything to say."

B. "*Well, that remark of mine wasn't very nice. I think you're really angry with me because you feel I've gotten you to say some unpleasant things about your mother—your one friend in the world. You put it on a physical basis, but you told me she stinks. Now you feel I attack and criticize your mother. You told me your father did somethng like that and you hated him for it. Now I'm doing it, and you hate me for it."*

H. "Well, I do feel somewhat that way. I felt you couldn't be very good —you don't know what you're doing. I guess that's why I wanted Dr. O'S."

B. Or hypnosis or some other painless process."

Mr. H. got going on a review of much that was told at the previous session, adding a few details here and there. This time he made many of the "interpretations" *I had made previously.* Several times he said, "I can see it better now" and concluded with, "I think I understand it now. I guess we were getting somewhere in the last session." Then, in a rather self-conscious manner, he said, "It's funny—now I keep thinking what swell guy you are—a little while ago I really did hate your guts."

I had said earlier when talking about the pain connected with this, that the confusion might be a good thing. Looking for a closing, I guess, I said, "Maybe our confusion has turned into a good thing today."

I feel now that he really had insight on Wednesday. In the interim, this insight became unbearable. He had to repect it—to *blame me* for a stupid error. By reviewing it, by reaching the same conclusions, he has come to accept it and to gain relief in acceptance. *I think he knows better now the origin and meaning of his aggression and why it frightens him.* He begins to see that more understanding of it can lessen the conflict over it. It is no longer a crime to think that mother can do no wrong. He seems to see how similar his present confusion is to the confusion of his adolescence.

Dr. O'S told me later that Mr. H. said, "I won't be needing that hour with you—I got things cleared up."

B.
Evaluation By Supervisor

The following material constitutes the supervisory evaluation of the psychotherapeutic work of Mr. B., covering the period from July 1948 to December 1948. This report will be supplemented by Mr. B.'s own evaluation, and a few concluding paragraphs which will be the result of a final conference between supervisor and supervisee which will be based on these two reports.

During the last six months Mr. B. had 18 supervisory conferences with me. He had one conference a week, but lost a few weeks because of the supervisor's vacations and one week because of the student's decision to use this week's time for preparation for his preliminary Ph.D. examinations.

Actually, the supervisor's observation of Mr. B.'s work reached farther back since Mr. B. was one of his students in a course on "Introduction to Psychotherapy" given in the school for clinical psychology during the winter term of 1947 and 1948, followed by a seminar on "Interpersonal Relationships in the Testing Situation" ending in the spring of 1948. Mr. B. was also a participant in the supervisor's seminar on "Interpersonal Relationships in a Psychotherapeutic Milieu", which was given at the medical service to which Mr. B. was assigned.

Mr. B.'s conception of psychotherapy before his experience in supervision can best be exemplified perhaps through a few paragraphs he wrote during his course on psychotherapy. He, as well as all other class members, was given a psychotherapeutic situation in which a patient comes to the doctor for help, feeling panic-stricken about his being unable to control erections in the men's shower-room. The students were asked to write down spontaneously what they might have said to the patient. Mr. B. gave the following response:

"I think we might be able to learn what causes you to have erections at such times and by so doing, free you from such an embarrassing situation. It is not something we can accomplish with a secret formula in a few minutes. So let's arrange for times when I can see you, and then we will start working on the problem. I think we might have our first appointment this afternoon. Mr. B. adds then the following comment: "I feel this is too big a problem to try to solve it in five minutes. I will try to give reassurance, as above, and some encouragement that our course of interviews will alleviate his difficulty."

I could not help but note his use of the words: "course of interviews" since this perhaps was well his conception at that time as to the nature of psychotherapy. He had done considerable interviewing during his army experience and had felt—and I think with justification—that he was a helpful person. A good many people who experienced having received help from him remained in contact, and sent him later on appreciative letters. One of his ideas of psychotherapy then was that the patient learn something in a course of interviews (parallel to the idea that one could learn something in a course on psychotherapy), and the other motive in his way of reacting to patients was that he wanted to be appreciated and loved and hoped that the patient would understand his wisdom.

During our supervisory conferences we developed a private language, such as saying that he acted toward patients as if he had to be their kind and clever uncle.

It seems to me that Mr. B. had exactly these two points in mind when suggesting, as basis for our mutual evaluation procedures, the interviews which he had with his patient on August 18 and on November 26. While actually his psychotherapeutic work started in July, he chose a comparatively late interview

since he felt that this was the end of the early period where he had really "diagnosed" with the help of supervision, his interviewing problem and wanted to see if he could change it.

The second interview is neither his best, nor his latest, but falls in a period where he felt that he had experienced for the first time his ability to change toward a new way of doing psychotherapy, of using himself.

At the point of dictating this I do not have the exact diagnosis of the patient on file but I conceive of him as a very disturbed person and while I feel that the word "borderline schizophrenic" does not say too much about him, it is at least an indication that Mr. B. got a difficult situation as his first one. The situation was made more difficult because the patient had to be transferred from his former therapist who left Topeka. The former therapist worked with this patient, if I'm correct, uncontrolled, and Mr. B. felt impelled, I suppose, to use himself as much as possible in a way similar to the patient's previous experience, since he did not want to lose the patient and had not yet confidence enough in trusting his own professional self.

The first interview of August 18 is a good example of the kind of psychic material which has dominated hour after hour the sessions of the patient's contact with the former therapist and later on with Mr. B. It was as if the therapist pushed the patient away from the present situation, did not make use of the interpersonal relationship that existed between patient and therapist, and encouraged the patient to wander off into childhood, to delve into schizoid fantasies, into a kind of textbook course of psychoanalytic theory. In spite of the terrifying nature of some of this phantasy material, both patient and therapist felt more comfortable in the realm of castration threats, seduction of mothers, homosexual fellatio experiences, and the like than in the coming to grips with each other about the problem of help.

Mr. B.'s use of himself, to quote from his first interview, was to get the patient "off the subject", "to get him back to the castration story", to ask him for explanations, to question the patient, to reassure him, to point out to him, to give him reassurance in terms of genetic explanations, to tell him that others do similar things, and that he wasn't really so bad since in his test folder he did not respond with "penis" to the stimulus word "suck" in one of the association tests.

His idea was to lead the patient back to pathological material of the past, to reassure him about it, and to avoid any hostility that the patient may express towards him during the therapeutic situation.

He truly was a good uncle full of wisdom who knew everything very well, who forgave, and who was moralizing and helped the patient to speak about everything except the present situation, except the psychotherapeutic situation, except the future, and except the real problems he had in taking help from this particular psychotherapist. Whenever the patient made a reference to receive such help, to get nearer to the psychotherapist, Mr. B. got "him off the subject."

It is, of course, only for the sake of pointing out the learning problem Mr. B. had that I am magnifying his difficulties in this way, thus almost indicating that Mr. B. was not a helpful person during this initial period. I do not want to give this impression and the best proof for his helpfulness consisted of the fact that the patient stayed with him and improved. It is not the basic helpfulness of Mr. B., his basic integrity, his desire to help that is questioned but the psychotherapeutic skill, the conscious use that he made of himself during his beginning months of therapeutic work.

The interview of November 26 demonstrates striking changes in the use Mr. B. made of himself. When the patient wonders if hypnosis could be tried to clear things up more quickly, Mr. B. did relate this to the painfulness of the psychotherapeutic experience, to some of the doubts that the patient had about Mr. B. He did dare to relate to the anger of the patient and rather than avoiding the subject was able to point it out to the patient without feeling uncomfortable, and could even stand the patient's attack when he suggested that he had arranged an interview with another doctor. He did not have to avoid the past in this new use he made of himself but was able to tie up the patient's past with the present therapeutic situation. He had thus learned to live and to work with the patient's ambivalence and also to face his own ambivalence.

It might well be useful to point out that a similar change did occur in Mr. B.'s use of his supervisory experience with me. He was always a pleasant student who asked careful questions and avoided conflict within the supervisory situation. Once during a meeting of the whole group while sharing the anger of one of the group members he did not express it when the evaluation procedure was discussed. Later, however, he was able to tell me how he had felt about it. In facing and in expressing his own ambivalence he learned to make different use of the supervisory conferences, of me as a teacher, and of himself as a learner. At first I suppose he had hope I, too, would be a good uncle full of wisdom for him who would always keep him in kind spirits. I think he has learned now that he can use me differently and without danger, and in turn has made a beginning step in a different use of himself as a psychotherapist.

Mr. B.'s use of the supervisory experience was adequate, very adequate. I certainly feel that he should be given continued opportunity to do suprvised psychotherapeutic work is he so desires. The experience with me was too short, I think, in order for Mr. B. to know how much of himself he was to put into psychotherapeutic work. He has interest and growing sensitivity for it. I understand from the new rotation schedule that Mr. B. will be working on the neurology section where there will be no direct opportunity for psychotherapy. He should be given an opportunity to finish his work with the present patient under supervision. I would be quite willing to undertake the responsibility of supervision if the Psychotherapy Council will allot the time for it. However, it is important, I think, that Mr. B. think of this new method of supervision as not only a learning experience but also as one that might help him more fully to decide how much psychotherapeutic work he wants to do in the future.

It is at the present time my impression that Mr. B. can and should do such pschotherapeutic work if he develops at the same rate. His future work assignment would have to be adjusted to this plan, or is it possible perhaps that he may be assigned to cases outside of this particular ward? As soon as Mr. B. feels ready for it he should let us know. I have also no objections to his taking more than one case.

Finally, I would want to add that mine was a very pleasant experience with him even though the going was rough at times. I hope that the Psychotherapy Council sees fit to accept the above recommendations.

Respectfully submitted,
Training Consultant.

Evaluation of Self and Supervisor in the Psychotherapy Training Program

The process notes of August 18 illustrate at least two of my major shortcomings as a therapist. The notes of this session epitomize all those which preceded it and many which followed. This report was selected because it made so obvious an error which my supervisor tried in vain to get me to recognize earlier.

My first difficulty, then, was a willingness and eagerness to flounder around in the patient's past to see what dark and startling secrets I could unearth. Early success at learning things which he had never told anyone else made me confident that I was a "born" therapist. The patient felt quite safe in remaining with childhood experiences and so required little urging to go back there. He learned quickly what sort of things to bring from psychodrama in order to keep us in the past. The "castration" topic (first two paragraphs) is an excellent example of this.

Then, in the third paragraph, when the patient tries to come back to the present, I consider this an error and get him back to castration as quickly as possible, in an awkward way (Par. 1, pg. 236). Incidentally, the interpretation at the end of that paragraph was obviously put in the patient's mouth and was not as spontaneous as the report might suggest. I'm sure this is also true for the "interpretations" on page 236. The patient was not gaining the insight I attribute to him. I was trying to demonstrate my skill at discovering and explaining his oral development in one easy lesson. The lecturing nature of that paragraph is also clear and illustrates another tendency of mine which I find it difficult to avoid.

But, I was proud of this session, as I was of others in which "discoveries" were made. I was provoked when Dr. E. was not impressed by any of it. Previous suggestions to keep the patient in the present were ignored. If I could do in two

months that which required a year of psychoanalysis, then it should be continued. There was real hostility toward the supervisor up to this time and a desire for a supervisor who would recognize my worth. With the notes on this session, however, he was able to open my eyes and to demonstrate that I was permitting and encouraging the patient to indulge in schizophrenic-like fantasies of homosexual and breast-sucking activities. With this incident, control sessions began to be cooperative rather than competitive affairs.

The second major criticism of my therapy technique is illustrated in the last few lines of these notes. It is the tendency to be the kind, approving, reassuring, sympathizing father figure. I mustn't make him angry at me; I must do and say things which will make him like and think highly of me. I must be careful not to cause him any pain. This difficulty, though now less pronounced, has been a persistent hindrance to the patient's free expression of feelings. Even now, when it is possible for the patient to show anger at me, I find it hard to refrain from comment which is aimed at dispelling his anger.

It is difficult to find favorable points in this report. A review of this period suggests that I did develop a relationship with the patient which was strong enough to withstand the dangers of anger and the pressure of reality when I was ready to bring him and myself to it. When I could avoid interpretations, I was able to provide some support. Giving opportunity for catharsis helped relieve some of the patient's guilt.

My greatest gain in this period was a slow but certain insight into the need for structure in a therapy situation. The structure is flimsy and wasteful if it consists only of an aimless exploration of childhood. I began to see that we could spend two more months or a year in similar wanderings without one bit of improvement in the patient.

I also began to see in this period that the supervisor was able to get a better picture of the process from my reports than I was able to get from writing them. I reached a point at which my attitude toward him changed from "how can I avoid his criticism" to "how can I make most use of his supervision." As this transformation took place, it was pleasantly surprising that the patient shared in the benefits.

The interview of November 26, although not free of some of the criticisms made above, shows a better ability to remain in the role of a therapist. It should be noted here that this session took place about two weeks after time structure had been applied to the relationship by setting a date for discharge. That was a sign for the patient to retreat into his childhood again. Now I was able to permit such a retreat because I had advanced far enough to keep the focus in the present, both for the patient and for myself.

This report shows a better ability to avoid lecturing and intellectual explanations, and in this avoidance, a better recognition of the feeling behind the patient's verbalizations. Earlier I answered the patient's request for hypnosis with an explanation somewhat like Freud's reasons for abandoning hypnosis. This time I was able to recognize the meaning of hypnosis for him and to respond appropriately.

The first page of the report suggests that my fear of hurting the patient has lessened. Consequently, he is able to express true feelings of hostility. However, after needling him into an angry outburst (page 237), I became apologetic and tried to smooth matters again. Undoubtedly I am relieved when (page 238) he says he likes me again.

In general, I believe with this interview, and particularly since then, I have reached a period in which continuing therapy training and supervision will be of greatest benefit. My roughest spots have received some smoothing but much more needs to be done, not only to become a skilled therapist (and not a preacher or explorer) throughout the therapy session. This can be accomplished with further practice and supervision, and with a variety of patients.

With present academic and work demands, such a program of training does not seem feasible or practical for me. In order to fulfill job requirements and to write a thesis, I will have to forego further training at this time. My patient is to be discharged soon. I would like to continue with him on an out-patient basis.

Some supervision will certainly be necessary. Perhaps the hours with the patient and with the supervisor can be reduced.

I am by no means ready to say that I want to do therapy exclusively. To be a good therapist I believe such a final decision is necessary.

...

Final Summary of Evaluation Conference

In our final evaluation we shared the material which we had prepared and we feel that there is consistent similarity. Mr. B. said that he felt about it as if we had written these evaluations together and at the same time.

We used this session in order to discuss one difference in these evaluations which relates to the future work of Mr. B. While the supervisor spoke of the possibility of Mr. B. doing continued psychotherapeutic supervised work with one or more patients, Mr. B. expressed in his evaluation the feeling that this present obligation towards the School (thesis), towards the Neurology Service, and also towards his family (in terms of completing his studies as quickly as possible and increasing his earning power) would not allow him to continue psychotherapy work at this particular moment. We discussed some of these external pressures which would prevent Mr. B. at present from allowing himself to bear the "internal pressures" that supervised psychotherapy would put on him. He is also not quite certain about his professional future, employment after Ph.D. or private practice, in Topeka or in another community.

While it is important for us to have the Psychotherapy Council know about the work done, and to acknowledge in terms of the choices it gives Mr. B. for the future, it must be stated that the practical decision for the moment will have to be that Mr. B. will do no more than finish with me his present case. Of course, if certain aspects of his present training, his present placement, work assignment, etc. might change, he and the Psychotherapy Council may want to rediscuss this decision.

Respectfully submitted,
E., Ph.D.

In this report it cannot be demonstrated but only stated that the most effective tool in learning is the supervisory relationship, the emotional ups and downs of the process. This relationship within the structural framework was different with each student but its skillful use was instrumental towards change in each situation and towards a decision which stemmed from the mutual evaluation. (The decision as to whether psychotherapeutic training ought to be carried on is of particular importance for psychologists who are beginning their training, who are really in the process of trying out whether they wish to use themselves in the psychotherapeutic function and whether they are suitable for such training).

In Joseph's and Potiphar's days the interpretation of the overseer, Joseph, was the final word and decided the future of those entrusted to him. Judging from many of the underlying feelings the supervisees expressed during the evaluation (which is only one phase albeit an emotionally charged one in the learning process) they project a role onto the supervisor which is not unlike the one of Joseph in the quarry. The freedom of their creative energies is reflected in their ability to take on much of the task of the evaluation and to discover, without undue fear,

their problems, their growth, their limits, and their real wishes and goals. They are usually stricter than the supervisor in evaluating themselves. No doubt, there is a Joseph in each of us, unrecognized and projected onto the supervisor.

The final responsiblity lies with the Psychotherapy Council but has proven an easy one to carry since the method itself seems to allow for mature personal evaluation procedures. The Psychotherapy Council, the administrative group, pleased with the work done, finds itself in a different position than the Pharaoh. The Council is not a punishing or elevating agency but a coordinating group, studying the problems of supervision and creating for supervisor and supervisee a structure within which and through which professional service and learning can proceed most effectively.

This presentation may have given the impression that the authors conceived of supervision as an activity directed toward the acquisition of skill only. The supervisory process implies, however, that attention is given to the development of the total professional self, of which skill is but a segment. It is also suggested that the learning process described is not one merely of imitation (although imitation and identification are essential accompanying factors in any kind of learning) but leads to a freeing of the self, a new creative use of the learning situation for self development.

The same holds true for the supervisor. Like Joseph he is an interpreter, an understander, a provider, and like Joseph his skill must be blended with all his creative and artistic powers. As he allows himself to be creative and to be free within the structure of his experience he creates for the student an atmosphere within which creative, mature growth is possible.

Inasmuch as such change is not always without pain it remains true that we all, may we be giving or taking, re-experience in supervision the fate of Joseph who moved from the pit and the quarry to the House of the Pharaoh. But could he predict it?

The 81st Annual Meeting of the Kansas Academy of Science

MINUTES AND REPORTS

The 81st annual meeting of the Kansas Academy of Science was held at Kansas State College, Manhattan, Kansas, April 28, 29, and 30, 1949. The Executive Council met at 3:00 p. m. on April 28, and was attended by F. W. Albertson, P. S. Albright, Standlee Dalton, D. J. Ameel, Robert Taft, W. J. Baumgartner and A. M. Guhl.

The secretary read a letter from Mr. Terlouw of the Eastman Kodak Company stating that none of his staff would find it possible to discuss visual aid in education on the date requested by the council. He did, however, indicate a desire to speak to the Academy. A discussion followed on the need for information and cooperation among teachers in science on the matter of visual aids. It was suggested that a display of scientific motion pictures be made at our next annual meeting.

The council members indicated an agreement to give some special attention to the Junior Academy of Science and to allot some funds to carry out such plans as may develop during the current meeting. Dr. P. G. Murphy had informed the secretary that Miss Margaret Parker would be willing to serve as chairman, if elected. Dr. W. J. Baumgartner suggested that Miss Edith Beach be considered as an additional associate editor of the Transactions to edit material for the Junior Academy.

It was moved and carried that the Council recommend a change in Section 9 of the Constitution to provide for six associate editors, adding one for the Junior Academy.

Upon the suggestion of Dr. F. C. Gates, by letter to the council, it was moved and carried that the council recommend an additional by-law providing that the incoming president appoint a nominating committee from among past-presidents.

The conditions under which research awards are made by the Academy were discussed. It was suggested that certain stipulations be made to which the recipient of an award should agree. It was moved and carried that the Secretary, the present committee chairman, and the incoming chairman act as a committee to formulate a statement of procedure for making awards.

The executive Council adjourned at 5:35 p. m.

The general business meeting on April 29, was opened at 11:15 a. m. The secretary made the usual announcements pertaining to the annual meeting.

The secretary gave a brief report. He stressed the need for certain sections to have sessions on the last day of the meetings as they had a large number of papers to present. As the majority of members attend the meetings on Friday only, the matter of additional sessions may present

problems for the program committee. The proposed changes in the constitution and by-laws were read.

The treasurer's report was given and accepted. A motion was made and passed to add the earnings for the year 1948-49, exclusive of that from the Reagan Bond, in the amount of $41.99 to the general fund.

The report of the Auditing Committee was made by H. A. Zinzer and accepted.

The report of the editor, Robert Taft, was presented and accepted. Volume 51 of the Transactions contained 496 pages. It was the first volume to be published within a calendar year. The four numbers of this volume included 37 original articles, minutes and reports of the Academy, the revised Academy constitution and by-laws, the membership list for 1948, four news sections, and seven editorials. Review articles were featured in each number.

The report of the managing editor, W. J. Baumgartner, was given and accepted.

Chairman W. J. Baumgartner of the Committee on State Aid reported that the Academy would receive $1250.00 yearly for a two-year period.

D. J. Ameel reporting for the Membership Committee stated that the Academy, as of April 15, 1949, had 63 new members, 29 resignations, and 453 with current dues paid. Additional payments were made during the meetings.

Chairman J. Breukelman of the Committee on Natural History Handbooks contemplates a resumption of activities as the cost of publication appears to be declining.

The report of the Academy Delegate, F. C. Gates, is printed in Vol. 51, pages 235-236.

The meeting adjourned at 11:50 a. m.

The main business meeting was called to order at 9:15 on April 30.

A change in Section 9 of the constitution was proposed to facilitate the activities of the Junior Academy of Science. It provided for an additional associate editor to assume the responsibility for the news of the Junior Academy. A motion to accept the changes was made and carried. The first paragraph of Section 9 should now read as follows: "The editorial board named in Section 8 shall consist of an editor, an assistant editor, a managing editor, and six associate editors. The members of this board shall be selected to include representatives of the major fields of science and of the Junior Academy of Science, and, with the exception of the assistant editor, shall be elected in the same manner as other officers of the Academy but for a period of three years."

A motion was made and passed to add the following By-Law XII:

"The incoming President shall appoint a Nominations Committee of at least five members, selected from past-presidents, one of whom shall be designated as the chairman."

The Committee on Educational Trends in Science Teaching is making plans to continue a study of high school science teaching in Kansas.

Members of the Committee on Conservation and Ecology stated that the past state legislature did not consider proposals made for Rock City Park.

E. O. Deere reported that the Committee for the Coordination of Scientific Groups and Public Relations has made a summary of scientific groups in Wichita.

A motion was made and carried requesting the secretary to invite a newly formed Kansas Ornithological Society to affiliate with the Academy.

Chairman P. S. Albright made the report for the Committee on Research Awards. Under the authority granted at the last annual meeting, the committee made the following three grants: to Milford W. Johnson of Fort Hays, the amount of $30.00; to Herman D. Smith of Manhattan $35.00; and to Charles Hess of McPherson $25.00. A motion was made and carried which approved these awards. The Committee recommended two awards for authorization, one to William A. Hertzer of Lawrence for $100.00, and the other to H. Wayne Trimm of Manhattan for $50.00 It was moved and passed that these awards be granted.

Reports were made either by papers given at sessions, or by sponsors, on the work done on these grants, as well as on those granted previously to L. J. Gier and Leon Lungstrom.

It was moved and carried to authorize the committee to grant interim awards not in excess of a total of $100.00 These awards are to be approved by the treasurer and the secretary.

The report of the Committee on Necrology was given by Roy Rankin and accepted. Robert B. Dunlevy of Winfield died on December 21, 1948, Edward G. Kelly of Manhattan on February 7, 1949, and H. H. King of Manhattan on March 11, 1949.

Mary T. Harman made the report for the Resolutions Committee, which was accepted.

Various helpful suggestions were made for our next annual meeting. Notable among these was one to hold the main business meeting after the dinner on Friday. It was also suggested that the presidential address follow the business meeting.

F. C. Gates presented the report of the Nominating Committee and the following officers were elected for 1949-1950.

President: Paul G. Murphy, Kansas State Teachers College at Pittsburg.

President-elect: P. S. Albright, Wichita University.
Vice-president: A. B. Leonard, University of Kansas.
Secretary: A. M. Guhl, Kansas State College.
Treasurer: Standlee Dalton, Ft. Hays Kansas State College.
Librarian: D. J. Ameel, Kansas State College.
Additional Members of the Executive Council:
F. W. Albertson, Ft. Hays Kansas State College.
J. R. Wells, Kansas State Teachers College at Pittsburg.
A. C. Carpenter, Ottawa.
J. C. Frye, University of Kansas.

Managing Editor: W. J. Baumgartner, University of Kansas (to 1952).

Associate Editors for the TRANSACTIONS (3 year terms)
(Psychology) Paul G. Murphy, Kansas State Teachers College, Pittsburg (to 1952).
(Junior Academy) Edith Beach, University of Kansas (to 1952).

Junior Academy Chairman: Margaret Parker, Kansas State Teachers College, Pittsburg.

The new president, Paul G. Murphy, took the chair and after a brief talk the meeting adjourned at 10:45.

The new Executive Council opened its session immediately after the main business meeting.

Annual meetings are scheduled for Wichita in 1950, Lawrence in 1951, McPherson in 1952, and Manhattan in 1953.

It was moved and carried that the council hold a meeting next fall in Manhattan.

It was moved and carried that tentative dates for the next annual meeting be set for April 27, 28, and 29, 1950.

A motion was made and passed asking the secretary to communicate with the chairmen of standing committees to obtain an outline of the work each plans to do, and for an estimate of the funds needed.

A motion was made and carried, to allocate up to $100.00 each for the committees on Conservation and Ecology, Education Trends in Science Teaching, and for the Junior Academy of Science.

A motion was passed asking the president to appoint a committee on visual aids in education. It was suggested that this committee arrange a contest and exhibit on visual aids for the next annual meeting. The president appointed F. W. Albertson as chairman.

The Executive Council adjourned at 11:30 a. m.

REPORT ON SECTIONAL MEETINGS

The chairmen of the sections, in general, reported successful meetings with good attendance. With most of the sections meeting concurrently there were some conflicts which were noted especially by the Agriculture and Physical Science Teachers sections. Some members indicated an interest in attending symposia in sections other than those of their particular specialization but found it inconvenient to do so. It was suggested that there be a geography section at the next annual meeting, with Karl Stacey as chairman.

A condensed report of sectional meetings is given in table 1.

Table 1

Section	*Chairman for 1949*	*Number of papers*	*Number attending*	*Chairman*
Agriculture	Harold Howe	22	68	(does not meet in '50)
Botany	R. L. McGregor	36	82	C. C. McDonald
Chemistry	W. G. Schrenk	18	160	B. L. Glendening
Entomology	L. W. Hepner	38	100	C. D. Michner
Geology	Frank Byrne	16	175	J. R. Berg
Junior Academy	Ralph Rogers		125	Margaret Parker
Psychology	Rudolf Ekstein	12	70	R. C. Challman
Physical Science Teachers	P. S. Albright	3	13	J. M. Michner
Physics	R. H. McFarland	19	75	T. F. Watson
Zoology	O. W. Tiemeier	83	27	H. E. Crow

The annual banquet was attended by 169 members.

A. M. Guhl, *Secretary.*

PROGRAM (REVISED) OF THE 81ST ANNUAL MEETING

Thursday, April 28

3:00 p. m. Executive Council Meeting, Fairchild Hall, Room 102
6:00 p. m. Sigma Xi Dinner, Thompson Hall.
8:00 p. m. Sigma Xi Meeting, Willard Hall.
"Changes in Body Composition with Human Growth." Dr. Genevieve Stearns, Department of Pediatrics, State University of Iowa.

Friday, April 29

8:00 a. m. Registration, Anderson Hall.
Exhibit, Photography-in-Science Salon, Anderson Hall.
Prints loaned by the AAAS.
9:00 a. m to 11:00 a. m. Sectional Meetings.
Agriculture, West Waters Hall, Room 212.
Botany, Dickens Hall, Room 108.
Chemistry, Willard Hall, Room 116.
Geology, Willard Hall, Room 115.
Physics, Willard Hall, Room 101.
Physical Science Teachers, Education Hall, Room 206.
Psychology, Education Hall, Room 204.
Zoology, Fairchild Hall, Room 102.
9:00 a. m. to 4:00 p. m. Junior Academy of Science, Willard Hall, Rooms 201 and 202.
11:00 a. m. to 12:00 noon. First General Business Meeting, Willard Hall, Room 101.
1:00 p. m. to 4:00 p. m. Sectional Meetings.
Chemistry, Willard Hall, Room 115 (2:00 p. m.)
Geology, Fairchild Hall, Room 202 (1:30 p. m.)
Other sections continued from the morning in the same rooms.

3:30 p. m. to 5:00 p. m. American Association of University Professors, Education Hall, Room 202.

4:00 p. m. to 5:00 p. m. Committee Meetings.

6:00 p. m. Banquet, Wareham Hotel.
Toastmaster, President Elect Paul G. Murphy.
Presidential Address, "Man's Disorder of Nature's Design", F. W. Albertson.

8:00 p. m. Public Address, Anderson Hall.
"Toward Industrial Peace and Cooperation", Edwin E. Witte, Chairman, Department of Economics, University of Wisconsin.

Saturday, April 30

8:00 a. m. to 12:00 noon. Geology Field Trip.

9:00 a. m. to 5:00 p. m. Kansas Entomological Society, Fairchild Hall, Room 202.

9:00 a. m. Main Business Meeting, Classroom Barracks, CA 101 (East of Willard Hall).

10:00 a. m. Executive Council Meeting, Classroom Barracks, CA 101 (East of Willard Hall).

AGRICULTURE

Chairman, Harold Howe

(Unless otherwise indicated, all speakers are staff members of the School of Agriculture, Kansas State College)
West Waters Hall, Room 212

Friday, April 29

9:00—10:00 a. m.

1. Results of Some Recent Animal Husbandry Research. Rufus F. Cox, Department of Animal Husbandry.
2. Studies in the Inheritance of Physical Characteristics in Dairy Cattle. Franklin Eldridge, Department of Dairy Husbandry.
3. Development of Marketing Research Under the Marketing Act of 1946. C. Peairs Wilson, Department of Economics and Sociology.
4. Some Recent Developments in Plant Propagation. R. A. Keen, Department of Horticulture.
5. The Inheritance of Aggressiveness of the Fowl. Richard C. Eaton, Department of Poultry Husbandry.
6. Corn Fertilizer Studies in Kansas—1948. V. H. Peterson, H. E. Jones, and F. W. Smith, K. S. C. Lantern, 10 min.

10:00—11:00 a. m.

The Application of Science to Japan's Agriculture. S. C. Salmon, Principal Agronomist in Charge of Wheat Investigation, U. S. Department of Agriculture, Beltsville, Maryland. Introduction by Dean R. I. Throckmorton.

1:00—2:25 p. m.

1. A Comparison of the Damage of the Freezes of November, 1940 and January, 1947 to Some Plant Materials. L. R. Quinlan, Department of Horticulture.
2. More Than Thirty Peach Varieties Survived Minus Thirty-two Degrees Fahrenheit. R. W. Campbell, Department of Horticulture.
3. The Influence of Wrapping Materials Upon the Keeping-Quality of Frozen Meat. Desmond B. Watt, Department of Animal Husbandry.
4. Some Bacterial Observations in Frozen Pork Sausage. Robert L. Hendrickson, Department of Animal Husbandry.
5. Corn Fertilizer Studies in Kansas—1948. Verlin H. Peterson, Department of Agronomy.
6. Iron-Manganese Ratios in Kansas Soils in Relation to the Occurrence of Iron Chlorosis of Plants. R. V. Olson of Agronomy.
7. Effect of Light on Male and Female Incubation in Pigeons. Herman D. Smith, Department of Poultry Husbandry.

8. The Problem of Parturient Mammary Edema in Dairy Cows. F. C. Fountaine, Department of Dairy Husbandry.

2:30—3:55 p. m.

1. Parity Under the Agricultural Act of 1948. Raymond J. Doll, Department of Economics and Sociology.
2. Problems in Plant Breeding. Elmer G. Heyne, Department of Agronomy.
3. Using Monosomic Wheat Plants in Genetic Studies. Ronald W. Livers, Department of Agronomy.
4. A Simple Color Test as an Aid in Grading Farm Separated Cream. T. J. Claydon, Department of Dairy Husbandry.
5. Economic Problems Involved in Soil Conservation. W. H. Pine, Department of Economics and Sociology.
6. The Effect of the War on Farm Partnerships. J. H. McCoy, Department of Economics and Sociology.
7. Supplementing Broiler Rations With Distillers Solubles. C. L. Gish, Department of Poultry Husbandry.
8. How Hens Perform in an Ideal Environment. Thomas B. Avery, Department of Poultry Husbandry.

4:00—5:00 p. m.

The Climate of Kansas. S. D. Flora, Meteorologist, Weather Bureau, U. S. Department of Commerce, Topeka, Kansas. Introduction by Dean Emeritus L. E. Call.

BOTANY

Chairman, R. L. McGregor

Dickens Hall, Room 108

Friday, April 29—9:00-11:00 a. m.

1. A new species of *Eudorina*. Travis E. Brooks, K. S. C. Lantern, 5 minutes.
2. Algae new to Kansas and a new species of *Oocystis*. R. H. Thompson, U. of K. Lantern. 10 minutes.
3. Flora of Clay County, Missouri. II, Algae. L. J. Gier and Alvin Bridges, William Jewell College, Liberty, Missouri. Lantern, 4 minutes.
4. Botanical notes for 1948. Frank U. G. Agrelius, K. S. T. C. Emporia. 10 min.
5. Kansas plants new to Kansas herbaria IV. W. H. Horr and R. L. McGregor, U. of K., 5 minutes.
6. Some techniques in preparing herbarium specimens. W. H. Horr, U. of K., 4 minutes.
7. The Keeping Quality of Cut Flowers as Affected by Some Common Chemicals. R. E. Mohler and Dale Eshelman, McPherson College.
8. Kansas Botanical Notes, 1948. Frank C. Gates, K. S. C., 5 minutes.
9. Distribution of Certain Species of *Taphrina* with special reference to Kansas. A. J. Mix and R. L. McGregor, U. of K. Lantern. 8 minutes.
10. Kansas Phytopathological Notes, 1948. C. O. Johnston, E. D. Hansing, L. E. Melchers and H. Fellows, K. S. C. Lantern. 15 minutes.
11. Victoria Blight of Oats. E. D. Hansing, K. S. C. Lantern 12 minutes.
12. Missouri Liverworts. L. J. Gier, William Jewell College, Liberty, Missouri. Lantern. 5 minutes.
13. Missouri Mosses. L. J. Gier, William Jewell College, Liberty, Missouri. Lantern. 4 minutes.
14. Preliminary report on the mosses of Kansas. R. L. McGregor, U. of K. 10 minutes.
15. A simple device for photographic copying. L. J. Gier, William Jewell College, Liberty, Missouri. 3 minutes.
16. *Melampodium leucanthemum* T. and G.: An Anatomical Study. L. D. Volle and W. A. Hetzer, U. of K. Lantern. 10 minutes.
17. Stomatal counts of Kansas species in certain genera of the Compositae. W. A. Hetzer, L. D. Volle and P. Hamilton Humfeld, U. of K. Lantern. 5 minutes.

18. The use of radioactive isotopes in plant physiological research. John C. Frazier, K. S. C. Lantern. 10 minutes.
19. The effect of hot water treatment on emergence of spring barley and control of smut. Lewis A. Shafer, K. S. C. 10 minutes.
20. Agropyron species as a source of new germ plasm in wheat breeding. John Schmidt, Fred Patterson, C. O. Johnston and E. G. Heyne, K. S. C. Lantern. 10 minutes.
21. Cytological studies in the genus *Nocardia.* N. McClung, U. of K. Lantern. 10 minutes.
22. Biological studies on the extracellular starch production by species of *Torulopsis.* L. E. Goyette, U. of K. Lantern. 8 minutes.
23. Antibiotic production in the Gymnoascaceae with reference to the nitrogen source. Lucille A. Paslay, K. S. C. 10 minutes.
24. Studies on Newcastle Disease Virus. L. D. Bushnell, K. S. C. Lantern. 10 minutes.
25. The combination of dyes with growing, resting and killed bacterial cells. John O. Harris, K. S. C. 10 minutes.
26. Bacteriologic or sanitary quality of rural school waters of Kansas as reflected by Riley County. Mary M. Green and P. L. Gainey, K. S. C. 10 min.
27. Kansas Mycological Notes, 1948. Travis E. Brooks, K. S. C. (By title)
28. The Root System of Ellis Sorghum and Its Development. Andrew Riegel. F. H. K. S. C. 10 minutes.
29. Top and Root Growth of Blue Grama Grass and Buffalo Grass in Relation to Frequency and Height of Clipping. Gerald W. Tomanck. F. H. K. S. C. 10 minutes.
30. Further Studies of Seasonal Height-weight Distribution in Native Prairie Grasses. John L. Launchbaugh, Jr. F. H. K. S. C. 10 minutes.
31. The Use of Colored Charts in Teaching Elementary Plant Taxonomy. William Eastman, Jr. F. H. K. S. C.
32. The Rhizophore of *Selaginella.* D. J. Wright, U. of K. Lantern. 10 minutes.
33. Further Studies of Seasonal Height-weight Distribution in Native Prairie Grasses. John L. Launchbaugh, Jr. F. H. K. S. C. Lantern. 10 min.
34. Top and Root Growth of Blue Grama Grass and Buffalo Grass in Relation to Frequency and Height of Clipping. Gerald W. Tomanck. F. H. K. S. C. Lantern. 10 minutes.
35. The Root System of Ellis Sorghum and its Development. Andrew Riegel. F. H. K. S. C. Lantern. 10 minutes.
36. The Use of Colored Charts in Teaching Elementary Plant Taxonomy. William Eastman, Jr. F. H. K. S. C. Lantern. 10 minutes.

CHEMISTRY

Chairman, W. G. Schrenk

Willard Hall, Room 116

Friday, April 29—9:00-11:00 a. m.

1. Factors Influencing Achievement in Freshman Chemistry. Harlan B. Johnson and Harold S. Choguill, F. H. K. S. C. 8 minutes.
2. Priestly Centennial—William K. Kedzie from Kansas. Sisters Mary Grace Waring and Mary Frances Dreese. Marymount College. 10 minutes.
3. Heat Stability of Fat Peroxides. D. B. Watt, J. L. Hall, D. L. MacKintosh and Gladys E. Vail, K. S. C. 10 minutes.
4. Rapid Determination of Collagen in Beef by Waring Blendor and Centrifuge Technique. Lois M. Hartley and J. L. Hall, K. S. C. 10 minutes.
5. Changes in the Vitamin A content of the Egg and Chick Embryo During Incubation. R. N. Williams, D. B. Parrish, J. S. Hughes and L. F. Payne, K. S. C. 10 minutes.
6. Effect of Fertilizer Treatment on the Chemical Composition of Wheat Grass in Southeast Kansas. William J. Johnson and W. G. Schrenk, K. S. C. 10 minutes.
7. An Assay of Stramonium. D. C. Brodie, L. D. Havenhill and F. Blair. U. of K. 8 minutes.

8. Short Demonstration Experiments in Aromatic Organic Chemistry. C. A. Vander Werf, U. of K. 10 minutes.
9. Surface Pressure Studies of certain Bitumens on various Aqueous Substrata. Duane L. Sawhill and A. C. Andrews, K. S. C. 15 minutes.
10. Rate of Attainment of Surface Equilibrium in Solutions of Paraffin Salts. Roland Hughes and W. J. Argersinger, U. of K. 10 minutes.
11. Electrochemical Behavior of Aluminum in Liquid Ammonia. A. D. McElroy, William E. Bennett, Jacob Kleinberg, U. of K. 15 minutes.
12. The Diffusion Constant of Pectinmethylesterase. Barbara F. Howell and A. C. Andrews, K. S. C. 15 minutes.

Symposium on Teaching of Chemistry
Willard Hall, Room 115

2:00 p. m.

1. American Chemical Society minimum requirements. Ralph E. Silker, K. S. C. 10 minutes.
2. Oxidation and Reduction, Electronic and Otherwise. Arthur W. Davidson, U. of K. 20 minutes.
3. Statistical Quality Control in College Analytical Laboratories. II. Chloride Determinations. O. W. Chapman, K. S. T. C., Pittsburg. 20 minutes.
4. Use of the Electronic Theory in Teaching Organic Chemistry. C. A. Vander Werf, U. of K. 20 minutes.
5. Technics and Devices for Teaching Organic Chemistry. L. C. Kreider, Bethel College. 20 minutes.
6. Research Projects for the Chemistry Major. Harold S. Choguill, F. H. K. S. C. 20 minutes.

ENTOMOLOGY

Chairman, L. W. Hepner
Fairchild Hall, Room 202

Saturday, April 30—10:00 a. m.-12:30 p. m.

1. The Western Corn-root Worm in Kansas. H. R. Bryson and D. A. Wilbur.
2. Overwintering of the Southwestern Corn Borer. James Wick.
3. Ectoparasite Recovery. Louis J. Lipovsky.
4. Sterpsiptera Collected at Manhattan. James B. Kring.
5. Kansas Bees of the Genus Agapostemon. R. L. Fischer.
6. The Genus *Osmia,* Subgenus Acanthosmiodes (wild bees). James R. White.
7. Flower Preferences in Wild Bees. Charles D. Michener.
8. Behavior of *Megachile brevis* Say in Tripping Alfalfa Blossoms. Norbert Kauffeld.
9. Relationship of Weather Factors on the Honeyflow. Joe Moffett.
10. Alfalfa Seed Yields Affected by Insecticides. W. W. Franklin.
11. The leafhopper genus *Typhlocyba.* Paul J. Christian.
12. The leafhopper tribe *Dikraneurini.* David A. Young.
13. The Tribe *Phlepsiini* (Cicadellidae) of North America, North of Mexico. Harold W. Crowder.
14. Morphological Studies on the Adult Hessian Fly. T. C. Gatie.
15. The Feeding Mechanism of the Adult Horseflies. Phillip Bonhag.
16. Important Entomological Problems of the United Provinces, India. T. P. S. Teotia.
17. Technique of Hermetically Sealing Insects in Vials for Display Purposes. R. L. Turner.
18. A Stain Technique for Differentiating Plant and Exoskeleton Fragments in Flour. Archie Armstrong.
19. Imbedding Insects in Plastic. Carl Stegmeyer.
20. Comments on Guatemalan Collecting. Roger Mitchell.
21. Toxicological Studies of Compound 118. Paul Dahm.
22. Biological Assay Method for Compound 118. Joe Pankaskie.
23. Insecticide Studies by Microinjection. H. E. Rife.
24. Mothproofing Tests. Carl Bauer.
25. Comparative Studies of the Newer Insecticides. Ted Brook.

26. Notes on Possible Phylogeny of Anisops. George T. Brooks.
27. Notes on the Biology of Rhagovelia. John A. Bacon.
28. Summary of Taxonomy of Saldidae. Burton B. Hodgden.
29. Studies of the Genus Buenoa (Notonectidae-Hemiptera). Fred S. Truxal.
30. Studies of the Family Gelastocoridae. Edward L. Todd.
31. Redbud Aphid, *Aphis pawneepae* Hottis. R. L. Parker.
32. Field Observations on *Cluex Tarsalis*. Leon Lungstrom.
33. Analysis of the Subject Matter in the Journal of the Kansas Entomological Society. George Dunn.
34. Transovarian Transmission of Tularaemia by the Tropical Rat Mite. Cluff E. Hopla.
35. Kiowa County Horn Fly Control Program. Del Gates.
36. Other Papers and Informal Remarks.
37. Report of the Department of Entomology, U. of K. H. B. Hungerford.
38. Report of the Department of Entomology, K. S. C. Roger C. Smith.

GEOLOGY and GEOGRAPHY

Chairman, Frank Byrne
Willard Hall, Room 115

Friday, April 29

A Symposium

9:100—12:00 a. m.

Ground-water Geology: Vinton C. Fishel, District Engineer, Ground-water Division, U. S. Geological Survey, Lawrence.

Petroleum Geology: Charles P. Walters, K. S. C., formerly Continental Oil Co.

Geology Applied to Highway Design and Construction: E. Dobrovolny, Engineering Geology Branch, U. S. Geological Survey, Denver, Colorado.

State Geological Surveys: John C. Frye, Executive Director, State Geological Survey of Kansas, Lawrence.

Training in Geology: Arthur B. Sperry, Head, Department of Geology, K. S. C.

Geology in the Federal Agencies: Alice S. Allen, Engineering Geology Branch, U. S. Geological Survey, Washington, D. C.

Military Geology: Charles B. Hunt, Chief, General Geology Branch, U. S. Geological Survey, Denver, Colorado.

Technical Papers

Fairchild Hall, Room 202

2:00—4:00 p. m.

Fracture Pattern in Riley County, Kansas: Arthur W. Neff, Amerada Oil Corporation, Midland, Texas; 10 minutes.

Cuspate Shorelines: Charles P. Walters, K. S. C.; 10 minutes.

Notes on the Ground-water Resources of Chase County, Kansas: Howard G. O'Connor, Kansas Geological Survey, Lawrence; 12 minutes.

Recent Trends in the Development of Alaska: Margaret Smith, K. S. C.; 10 min.

Soy Beans in Midwestern Farming: Sara C. Larson, K. S. C.; 12 minutes.

Peanut Industry of the Southern States: Huber Self, K. S. C.; 12 minutes.

A Geological Cross Section from Marshall County to Chautauqua County, Kansas: John M. Jewett, Kansas Geological Survey, Lawrence; 10 minutes.

Pleistocene Drainage Patterns in Central Kansas: O. S. Fent, consulting geologist, Salina.

Notes on the Paleoecology of the Permian System in Riley County, Kansas: Melville R. Mudge, U. S. Geological Survey, Manhattan; 10 minutes.

Field Trip

Saturday, April 30—8:00-12:00 a. m.

Fairchild Hall, Room 1

Pleistocene Geology in Riley, Pottawatomie, and Wabaunsee Counties, Kansas: leaders, Henry V. Beck, Frank Foster, and Melville R. Mudge.

JUNIOR ACADEMY OF SCIENCE OF KANSAS

Chairman, Ralph Rogers
Willard Hall, Rooms 201 and 202

Friday, April 29—9:15 a. m.-4:00 p. m.

Registration 9:15 a. m.
Program 10:30 a. m.

Papers or demonstrations will be presented by science clubs. The program will be announced at the meeting. Membership dues of $2.00 per club should be sent to Mr. Standlee Dalton, Fort Hays Kansas State College, Hays, Kansas. For information write to Mr. Ralph Rogers, Manhattan Senior High School.

PSYCHOLOGY

Acting President, Rudolf Ekstein
Education Hall, Room 204

Friday, April 29, Morning Sessions

9:00—10:00 a. m.

Symposium: "Licensure and Certification of Psychologists in Kansas". Chairman, Joseph E. Brewer, Wichita Guidance Center.

1. The problem and history of solutions in other states. Helen D. Sargent, Winter Veterans Administration Hospital, Topeka. 15 minutes.
2. History of attempts to deal with the problem in Kansas. Edwina Cowan, Wichita. 15 minutes.
3. A suggested solution for Kansas. Joseph E. Brewer, Wichita Guidance Center. 15 minutes.

10:00—11:00 a. m.

Meeting of Board of Directors of Kansas Psychological Association. (Open to all members.) Followed by Business Meeting of Kansas Psychological Association.

Afternoon Sessions

2:00—3:00 p. m.

Chairman of first session: Robert C. Challman, Menninger Foundation, Topeka, Kan.

4. Changing orientations toward the role of psychological factors in psychopathology. Henry Pronko, F. W. Snyder, and G. W. Allen, University of Wichita. 10 minutes.
5. An experimental project in supervision in clinical psychology. (1. Psychotherapy.) Rudolf Ekstein, Menninger Foundation and Helen Sargent, Winter Veterans Administration Hospital, Topeka. 15 minutes.
6. The psychological test report in diagnostic examination: Agreement with clinical diagnosis. Walter Kass, Menninger Foundation, Topeka. 12 min.
7. The clinical application of a battery of psychological tests in the study of delinquents: A case report. George H. Weber, Kansas Boys' Industrial School, Topeka. 10 minutes.

Intermission

3:00—4:00 p. m.

Chairman of Second Session: Paul G. Murphy, K. S. T. C.

8. The day record as a psychological method. Dr. Roger G. Barker and Herbert F. Wright, U. of K. 12 minutes.
9. An outline of semantics for the psychologist. Fred V. Gardner, University of Wichita. 10 minutes.
10. Relationship of mean scores on the Strong, Kuder and Bell Inventories with the MMPI M-F scale as a criterion. William C. Cottle and Jackson O. Powell, Guidance Bureau, U. of K. 8 minutes.
11. Effect of phenobarbital on learning in white rats. William T. Wright, K. S. C. 10 minutes.
12. Some factors that affect the shape of the curve of fatigue. J. A. Glaze, K. S. T. C. Pittsburg. 8 minutes.

4:00 p. m.

Dr. Baker, Head of the Education and Psychology Department at Kansas State College and Dr. Roy C. Langford invite all the psychologists and their guests to an open house after the day's program at the home of Dr. Langford.

PHYSICAL SCIENCE TEACHERS

Chairman, Penrose S. Albright
Education Hall, Room 206

Friday, April 29—9:00 a. m.

1. Teaching Electricity by Drawing and Explaining Circuits. Blaine E. Sites, High School, Salina. 10 minutes.
2. The Nutrino with particular emphasis on the researches on this particle conducted at Kansas State College. H. M. Froslie, K. S. C. 30 minutes.
3. Cosmic Rays. A. B. Cardwell. K. S. C. 30 minutes

PHYSICS

Chairman, R. H. McFarland
Willard Hall, Room 101

Friday, April 29—8:30-11:00 a. m.

1. Infrared Investigation of Oxidation Mechanisms. S. E. Whitcomb, K. S. C. 5 minutes.
2. Collodial Particles Size Determination by X-Ray Scattering. R. D. Dragsdorf, K. S. C. 5 minutes.
3. A Possible Expression of the Charge Density in an Electron's Nucleus. E. R. Lyon, K. S. C. 5 minutes.
4. Proper Mixtures of Ellis County Soil for Adobe Construction and Their Physical Properties. B. W. Read, W. G. Read, and H. A. Zinszer, F. H. K. S. C. 8 minutes.
5. Alpha-Particles Autoradiographic Studies. F. E. Hoecker, U. of K. 8 minutes.
6. Characteristics of the Atmospheric Pressure Alpha-Particle Detector. J. DeLord, U. of K. 8 minutes.
7. Photoelectric and Thermionic Properties of Nickel. A. B. Cardwell, K. S. C. 5 minutes.
8. Electronic Spectra of Diatomic Molecules. H. M. Froslie, K. S. C. Lantern. 5 minutes.
9. Electrical Resistance of Thin Films. P. W. Ott, U. of K. 8 minutes.
10. Gold Chromium Standard Resistance. C. F. Oakley, K. S. C. 5 minutes.
11. Dielectric Measurements at Microwave Frequencies. M. E. Olmstead, K. S. C. 5 minutes.
12. Solarization and its Use for Reproduction of Photography Negatives. A. E. Bridges, William Jewell. Lantern. 8 minutes.
13. The Status of the K. U. Electrostatic Generator. L. W. Seagondollar, U. of K. 8 minutes.
14. Construction of a Zinn Type Ion Source for the K. U. Generator. R. K. Smith, U. of K. 8 minutes.
15. Control System of the K. U. Generator. W. R. Alexander, U. of K. 8 min.
16. A Potential Function for Van der Waal's Forces. B. Leaf, K. S. C. 5 minutes.
17. Transitors. W. Fiden, K. S. C. 5 minutes.
18. Absorptions Spectrum from a Mixture of Sodium and Lithium Vapors. B. B. Phillips, K. S. C. 5 minutes.
19. Scintillation Counters for Radiation Measurement. C. Stevens, K. S. C. 5 min.

1:00—4:00 p. m.

Applications of Glow Discharge Tubes, J. Brewer, Midwest Research Institute. 30 min.

The Objectives to be Considered in Teaching Physics to College Students, S. W. Cram. E. S. T. C. 60 min.

Planning of the Curriculum to Keep in Step with the Times, W. D. Bemmels, Ottawa University 60 min.

A laboratory experiment on Acoustical Impedance and Absorption Coefficient, W. A. Hilton, William Jewell College, 10 minutes.

ZOOLOGY

Chairman, Otto W. Tiemeier
Fairchild Hall, Room 102

Friday, April 29—9:00-11:00 a. m.

1. Plankton in Lyon County State Lake, 1948. Ivan J. Shields, U. of K. Lantern, 5 min.
2. A Review of Kansas Limnology. John Breukelman, Ted F. Andrews, K. S. T. C. Emporia and Roy Schoonover, Fish and Game Comm., Lantern, 10 min.
3. The Jumping Mouse in Kansas. Rollin H. Baker and E. Lendell Cockrum, U. of K. Museum, Lantern, 5 min.
4. Coyote-Dog Hybrids. James W. Bee and E. Raymond Hall, U. of K. 5 min.
5. The Significance of Interspecific Hybrids in Speciation. Charles G. Sibley, U. of K. Lantern, 8 min.
6. Origin of the Vertebrates: A Synthesis of Present Knowledge. T. H. Eaton, Jr. Southwestern College, Lantern, 15 min.
7. Variation in the Scale and Color Pattern of the Wandering Garter Snake, in Utah and Southern Idaho. Wilmer W. Tanner, U. of K. and A. Kent Christenson, Provo, Utah. 5 min.
8. The Economic Status of Coyotes in Kansas. Robert Boles, Manhattan and H. T. Geir, K. S. C. Lantern, 12 min.
9. Coyote Studies: Reproduction. H. T. Geir, K. S. C. Lantern, 12 min.
10. Wildlife Cover in Kansas. Harold C. King, Fish and Game Comm. 8 min.
11. Studies of the Productivity of Trichinella spiralis and of its Larval Locations. R. L. Tugwell, K. S. C. Lantern, 10 min.
12. Cats of Eastern Kansas as Helminth Hosts. J. E. Ackert and H. H. Furomoto, K. S. C. Lantern, 6 min.
13. Some Intestinal Parasites of the Coyote. Gordon Fairchild and D. J. Ameel, K. S. C. Lantern. 10 minutes.
14. A Survey of the Helminths of Dogs from the Vicinity of Manhattan. E. S. M. Gaafar and D. J. Ameel, K. S. C. Charts, 6 minutes.
15. Helminths of the Centrarchid Fishes of Crawford County, Kansas Strip Pits. E. M. Leonard and Claude Leist, K. S. T. C., Pittsburg. Lantern. 5 min.
16. Some Effects of Vitamin C-deficiency upon the Male Guinea Pig. Mary T. Harman, K. S. C. 10 minutes.
17. Newer Pregnancy Tests. E. H. Herrick, K. S. C. Lantern. 10 minutes.
18. Growth of the Heart and the Lungs in the Fetal Dog. Homer B. Latimer, U. of K. Lantern. 10 minutes.
19. Synchronization of the Sexes in Flocks of White Leghorns. A. M. Guhl, K. S. C. Lantern. 10 minutes.
20. Bird Studies: Some New and Infrequent Visitors to Kansas. R. E. Mohler, McPherson College, Richard H. Schmidt and Frank W. Roble.
21. A Study of Longevity in McPherson County, Kansas. R. E. Mohler and Carl Dell, McPherson College.
22. The Os Opticus of Birds. Otto W. Tiemeier, K. S. C. Lantern. 10 minutes.
23. Contributions of Kansas to Health of the State, the Nation, and the World. W. J. Baumgartner, U. of K. (By Title.)
24. Taxonomic status of the Townsend Ground Squirrel (*Citellus townsendii*). Theo. H. Scheffer. U. S. Biological Survey. (By Title.)
25. An Unusual Hernia in a Newborn Puppy. Homer B. Latimer, U. of K. (By Title.)
26. Relative Growth of the Organs in the Fetal and Newborn Cat. Homer B. Latimer, U. of K. (By Title.)

26\. The Incidence of Intestinal Parasites in One Hundred Thirty-four College Students. Jennie Spoelstra and Mary E. Larson, U. of K. 4 minutes.

An Analysis of Two-hundred Stool Examinations of Chickens. Charles F. Smith and Mary E. Larson, U. of K. 4 minutes.

Kansas Chapters
AMERICAN ASSOCIATION OF UNIVERSITY PROFESSORS
Cecil H. Miller, Kansas State College, Manhattan, presiding
Education Hall, Room 202
Friday, April 29—3:30-5:00 p. m.

"UNESCO" Today." Kenneth S. Davis.

Mr. Davis, a Kansan, is assistant to the chairman of the National Commission For UNESCO and recently attended the conference at Beirut, Lebanon. He is the author of two novels and a biography of General Dwight Eisenhower.

"Some Fields of Activity for the AAUP." Edwin O. Stene.

Professor Stene of the University of Kansas is an elected member of the board of directors from this AAUP district and has for many years been a most enthusiastic and valuable member of the AAUP.

Techniques in Preparing Herbarium Specimens

W. H. HORR
University of Kansas, Lawrence

Those who work in herbaria are often faced with problems which are annoying and time consuming. The author will describe how three of these problems are handled at the University of Kansas.

1. The drying of succulents is usually slow, and the results unsatisfactory. This result is especially true if the work is done in the field. I have had cacti stems send out new growth after being in a press from early June until September. If the stems are split and the specimens placed for a few minutes in 70% alcohol containing 0.05% bichloride of mercury before being put into the drying press, they will dry quite readily and without discoloration. This alcohol-bichloride of mercury treatment is very effective in the prevention of flower decay in such plants as the yucca and portulacca.

2. When mounting a specimen, by the use of glue on a glass plate, a sheet of cellophane placed over the specimen while it is drying will prevent its sticking to anything except the mounting paper.

3. If the specimen being mounted has thick stems, a sheet of "paper felt" such as that often used in packing glassware and instruments, placed over the cellophane, will press the leaves and floral parts down onto the mounting paper.

Transactions Kansas Academy of Science, Vol. 52, No. 2, 1949.

Kansas Botanical Notes, 1948[1]

FRANK C. GATES
Kansas State College, Manhattan

The spring of 1948 was long-drawn out and unsatisfactory for field work. A temperature of minus 6° F. occurred as late as March 11.

So few unusual happenings in the plant world occurred during the year that that in itself is worth mentioning.

Orobanche (Myzorrhiza) ludoviciana was found by Mr. H. H. Westmeyer growing on the roots of tomato plants in his garden. This plant is normally parasitic on composites and I have never found it except on the roots of Xanthium.

We would call attention to the fine county description and flora by R. L. McGregor for Douglas County (Trans. Kans. Acad. Sci. 51: 77-106 1948.).

We take pleasure also in calling attention to the very fine pictorial work, *Wild Flowers of Kansas,* by Professor W. C. Stevens, retired professor of botany of the University of Kansas, my review of which appeared on pages 430-431 of volume 51 of these *Transactions.*

During the year herbarium activity was greater than for many years. Specimens aiding important county records were received from the following: Lon C. Clark, Leavenworth Co.; L. W. Compton, Labette Co.; F. C. Gates, Atchison Co.; V. V. Geissler, Wilson Co.; W. W. Holland, Crawford Co.; Nellie B. Jacobs, Crawford and Labette counties; Alan Laing, Republic Co.; Lambert & Dickerson, Brown Co.; R. L. McGregor, Douglas Co.; Emma Maupin, Stafford Co.; H. H. Munger, Pottawatomie Co.; J. Plunkett, Ottawa Co.; Sarah Shoner, Chase Co.; A. J. Stange, Smith Co.; Frank Swink, Stevens Co.; and H. W. Westmeyer, Ford Co.

Plants added to the state list during the past year have been mainly due to the activity of W. H. Horr and R. L. McGregor in the eastern part of Kansas (Trans. Kans. Acad. Sci. 51: 212-214. 1949.). They include among others the following, definite specimens of which have been filed in the herbarium at the University of Kansas:

Leonurus marrubiastrum L., Douglas Co., new.

Humulus japonicus Sieb. & Zucc., Shawnee Co., previously only reported.

Hydrangea arborescens L., Cherokee Co., new.

Transactions Kansas Academy of Science, Vol. 52, No. 2, 1949.

[1] Contribution No. 501, Department of Botany and Plant Pathology, Kansas State College of Agriculture and Applied Science.

Polygonum sagittatum L. (as Tracaulon sagittatum (L.) Small), Douglas Co., new.

Ranunculus micranthus Nutt., Cherokee Co., new.

Solidago riddellii Frank (as Oligoneuron riddellii (Frank) Rydberg), Osage Co., new.

Solidago wardii Britton, Montgomery Co., new.

Vincetoxicum carolinense (Jacq.) Britton, Cherokee Co., new.

Centaurium texense (Griseb.) Fern., Montgomery Co., new.

Heliotropium indicum L., Cherokee Co., previously only reported.

Panicum helleri Nash, Douglas Co., new.

Wolffia punctata Griseb, new to the state, was found in Cloud County by S. V. Fraser.

Interest in Kansas liverworts and mosses has reawakened after a long lapse.

Transactions
Kansas Academy of Science

Volume 52, No. 3 September, 1949

The Geography of Kansas

WALTER H. SCHOEWE
State Geological Survey and Departments of Geology and Geography
University of Kansas

In our issue for September, 1948, Dr. Schoewe began this series with an extensive review of the political geography of the State, a review which attracted wide and favorable attention. In the present issue, Dr. Schoewe considers in detail the physiography of Kansas, which in aspect as most Kansans know, is far from being a broad flat plain—the prevailing view of many, many people. How far wrong this prevailing view happens to be can best be determined by a reading of the present article. In reviewing the physiography of the State in detail, Dr. Schoewe has taken special care to call attention to the many scenic areas and features with which we are blessed. Many excellent photographs and maps emphasize this aspect of our geography and detailed directions for reaching these scenic points have been amply provided in the review which follows.

For a brief biographical sketch of the author, see our September, 1948, issue, page 289. —The Editor

Part II
PHYSICAL GEOGRAPHY
Geology

The basic foundation upon which agriculture, industry, topography, and geographic development of any state depends is the geology of that state. The rocks furnish the soil and contain the mineral resources so vital for man's existence and progress. The soil is fundamental for the growing of crops and is the basis upon which all agricultural industry rests.

Surface rocks.—Essentially all the surface rocks of Kansas (Fig. 12) are of sedimentary origin and consist chiefly of shale, sandstone, limestone, gravel, sand, silt, and clay,—rocks ranging in age from the Mississippian to the present (Table 10) and representing a span of time of more than 200 million years. The aggregate thickness of the surface rocks is approximately 10,000 feet.

The oldest surface rocks are of Mississippian age and crop out over an area of approximately 50 square miles in the extreme southeast corner

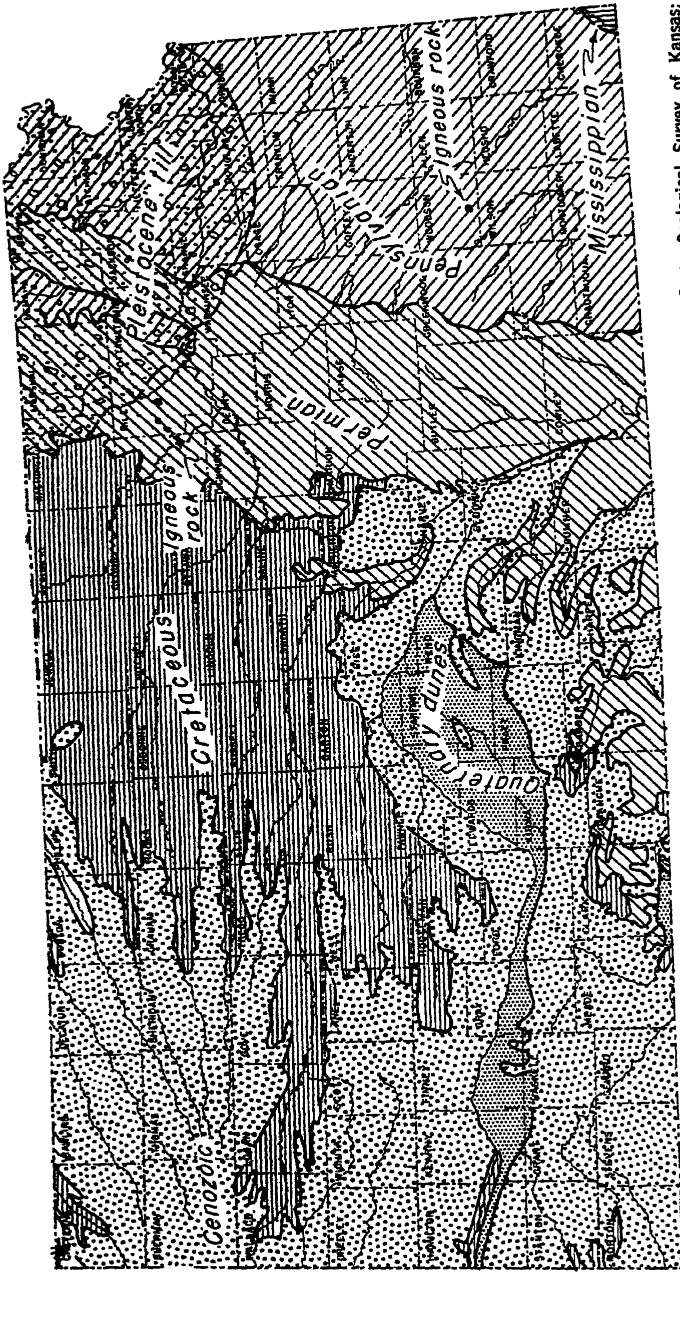


Fig. 12. General geologic map of Kansas showing distribution of major units of outcropping rocks. (Courtesy State Geological Survey of Kansas; Tolsted and Swineford, 1948).

of the State in Cherokee County (Fig. 12). The rocks consist in the main of cherty limestones which on the average are some 50 feet thick. Economically these Mississippian rocks are of great importance to the State for they contain the valuable zinc and lead ores.

To the west of the oldest Kansas Paleozoic surface rocks are alternating marine and nonmarine shales, limestones, and sandstones of Pennsylvanian age also belonging to the Paleozoic System of rocks. These rocks form the surface strata for the eastern one-fourth of the State, extending as far west in the south as Cowley County and to the

Table 10.—Chart showing geologic age, kind and thickness of rocks, economic mineral resources of Kansas rocks, and duration of geologic periods

Era Duration, million years	Period	Epoch	Duration of period, million years	Rock	Thickness in Feet: Surface	Thickness in Feet: Subsurface	Economic Mineral Resources
		Recent		Sand, silt, clay, gravel, loess	350	......	Sand, gravel
	Quaternary		2				
		Pleistocene		Sand, gravel, silt, clay, volcanic ash, till, loess, caliche	100-550	......	Sand, gravel, volcanic ash
Cenozoic 60		Pliocene		Gravel, sand, silt, clay, caliche	30-350	......	Sand, gravel, ground water, volcanic ash
	Tertiary	Miocene	58				
		Oligocene					
		Eocene					
	Cretaceous		65	Chalk, limestone, sandstone, shale, quartzite	2,750	......	Chalk, clay, lignite, artesian water, gas, stone
Mesozoic	Jurassic		32			?	
125	Triassic		28	Siltstone, sandstone, gypsum	40?	?	
	Permian		38	Shale, limestone, sandstone, gypsum, rock salt	3,000	......	Salt, oil, gas, gypsum
	Pennsylvanian		48	Limestone, shale, sandstone, coal	3,100	......	Coal, oil, gas
	Mississippian		38	Limestone	50	1,400	Lead, zinc, oil, gas
Paleozoic	Devonian		45	Limestone, dolomite	......	......	Oil, gas
368	Silurian		27	do	......	550	Oil, gas
	Ordovician		67	Limestone, dolomite, sandstone	......	500	Oil, gas
	Cambrian		105	do	......	1,000	Oil, gas
Proterozoic			900	Granite, quartzite	......	......	Oil
Archaeozoic			550	Schist, gneiss	......	......	

middle of Brown County in the north (Fig. 12). The Pennsylvanian surface rocks of Kansas are composed of more than 65 rock units or formations totaling on the average 3,100 feet and containing at least 53 coal seams of which 14 are being mined at present. North of Kansas River and as far west as Big Blue River east of Manhattan, the Pennsylvanian rocks in many places are masked by a mantle of glacial drift and wind-blown silt or loess.

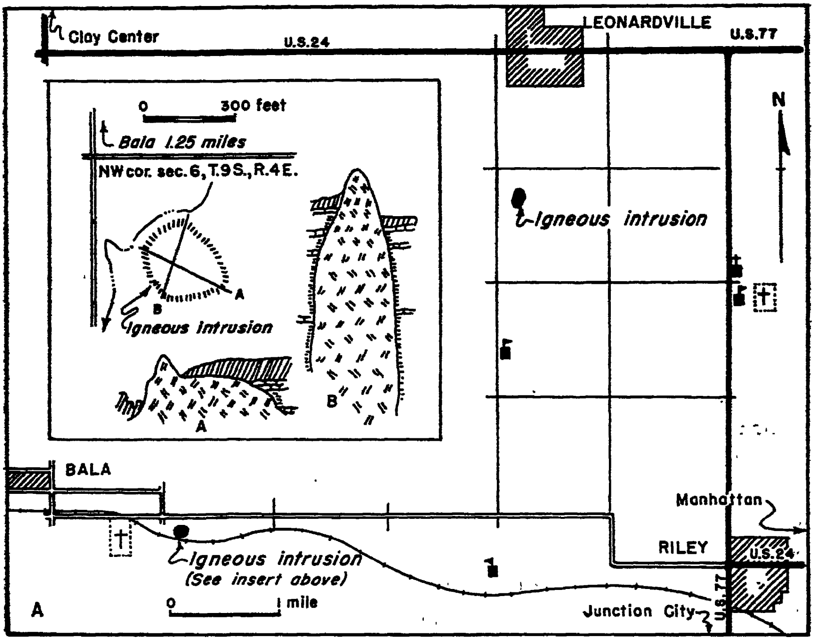
Paralleling the area of Pennsylvanian rocks on the west is a north-south belt approximately 50 to 70 miles wide in which the surface formations are of Permian or upper Paleozoic age (Fig. 12). In the southern part of the State the Permian strata crop out as far west as Meade County. The Permian rocks, of which there are 40 formations or rock units, total about 3,000 feet and consist of limestones, shales, chert or flint, gypsum, rock salt, and red-colored siltstones, sandstones, and shales. The limestones, shales, and chert or flint beds make up the well-known Flint Hills or Blue Stem grass area, whereas the red beds form the surface rocks west of Arkansas River in the counties bordering the Kansas-Oklahoma state line. The Kansas Permian rocks are noted for their salt and gypsum formations, both of which are mined extensively in the State.

North-central Kansas is underlain essentially by rocks of Cretaceous or uppermost Mesozoic age (Fig. 12). The rocks consist for the most part of varied-colored clays, siltstones, and sandstones of the Dakota formation and alternating beds of limestones, chalk, and shales. The Cretaceous rocks are about 2,750 feet thick and are divisible into 8 rock units or formations. The Dakota formation serves as a great reservoir, or aquifer, for underground waters and also as a source of high-grade ceramic materials and some lignite or brown coal. The chalk beds and limestones have been used extensively for construction purposes and have made Kansas world-famous because of the exceptionally fine specimens of fossil reptiles which they have yielded.

The surface rocks of the remaining part of Kansas consist of Tertiary and Quaternary or Cenozoic formations composed for the most part of poorly to noncemented gravels, sands, silts, and clays (Fig. 12). The Tertiary rocks total about 350 feet and are made up of 4 formations whereas the Quarternary deposits comprise 13 rock units aggregating about 550 feet in thickness. The extensive sand and gravel deposits, as well as the volcanic ash beds, exploited in the State are of Cenozoic age.

Of the three classes of rocks—igneous, sedimentary, and metamorphic—igneous rocks *in situ* occur in Kansas in only two counties, Riley and Woodson (Figs. 13, 14 and 15). The Riley County igneous rocks are greenish, fine-grained basic volcanic rocks. Outcrops of these rocks, each less than an acre in extent, occur at three localities. One of the occurrences and the one most accessible is about 1½ miles east of Bala in sec. 6, T. 9 S., R. 5 E. (Fig. 15A). A second outcrop is 1½ miles south of Leonardville in sec. 22, T. 8 S., R. 5 E. (Fig. 15B) and the third outcrop (Fig. 15C) is about 5 miles northwest of Stockdale in sec. 23, T. 8 S., R. 6 E. These igneous masses are probably of Cretaceous

age and have been interpreted as possible volcanic necks or plugs. More recently Dreyer (1947, p. 22) on the basis of a magnetic survey



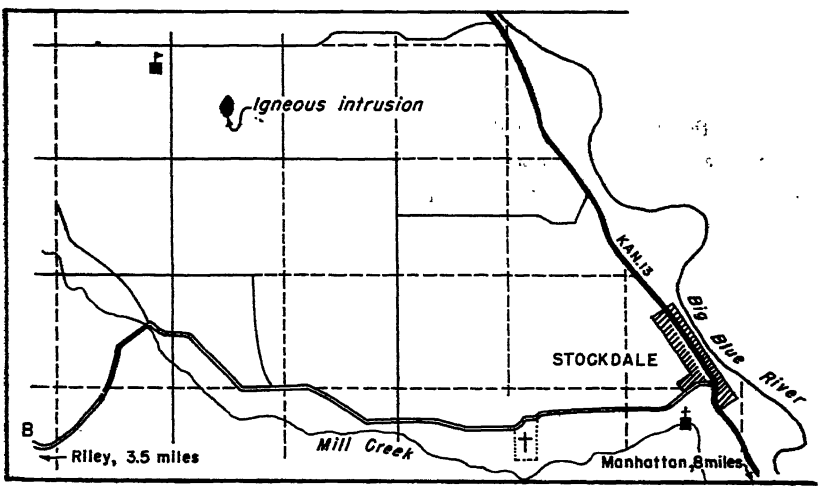


Fig. 13. Map showing locations of igneous rock outcrops in Riley County, Kansas (A) near Bala and Leonardville. After Dreyer, 1947. (B) near Stockdale.

has interpreted the Bala igneous mass as a vertical, eastwardly plunging dike. Exact locations of the Riley County igneous masses are shown on Figure 13.

In Woodson County about 7 miles south of Yates Center in sec. 13, T. 26 S., R. 15 E., and in sec. 18, T. 26 S., R. 16 E., boulders of granite and granite porphyry are found scattered over an area of about 120 acres (Fig. 14). Most of the boulders, many of which have a diameter of more than $1\frac{1}{2}$ feet and one of which has a diameter of nearly 7 feet, are associated with low mounds. The origin and age of these granite boulders is still in doubt. Twenhofel (1917, p. 363), who discovered the boulders in 1915, originally was of the opinion that they reached their position near Rose in Woodson County through the agency of ice, either glacial or ice-rafted, preferably the latter, at the same time that the Pennsylvanian shales with which they are associated were deposited and that therefore they are of Pennsylvanian age. Later, however, Twenhofel (1926, p. 411) discarded the hypothesis of ice action and concluded that the granite boulders are the surface exposures of a granite mass that was intruded into the Pennsylvanian and lower strata some time during Tertiary or earlier times. Powers (1917, p. 146) considered the boulders Pennsylvanian in age and suggested that they were derived from a granitic knob which was exposed at the time of deposition of the associated shale, a view held untenable, however, by Moore (1918, p. 104). Knight and Landes (1932, pp. 2, 6-8, 14, 15) explained the igneous rocks near Rose as of laccolithic origin. Jewett (1941, pp. 96-99) described the Riley County igneous intrusions and stated that they are probably of Cretaceous age. The Woodson County granite rocks he and Abernathy (Jewett and Abernathy, 1945, p. 21) considered to be a post-medial Pennsylvanian granite dike.

In the western one-half of the State as well as in northeastern Kansas are extensive deposits of gravel consisting of pebbles, cobbles, and boulders and also sand, silt, and clay. Many of the coarser materials are composed of granites and other igneous rocks as well as quartzites, gneisses, and schists, rocks brought to their present location by streams or by glaciers. These deposits, however, although originally of igneous and metamorphic origin, are not native to our State but are transported materials and hence are classified by geologists as sedimentary rocks.

Subsurface rocks.—Buried beneath the surface rocks are other and older sedimentary rock formations including those of Devonian, Silurian, Ordovician, and Cambrian age, all belonging to the Paleozic Era (Table 10, Fig. 16). These rocks are in all respects similar to the surface formations and total about 3,500 feet in thickness. Many of the sub-

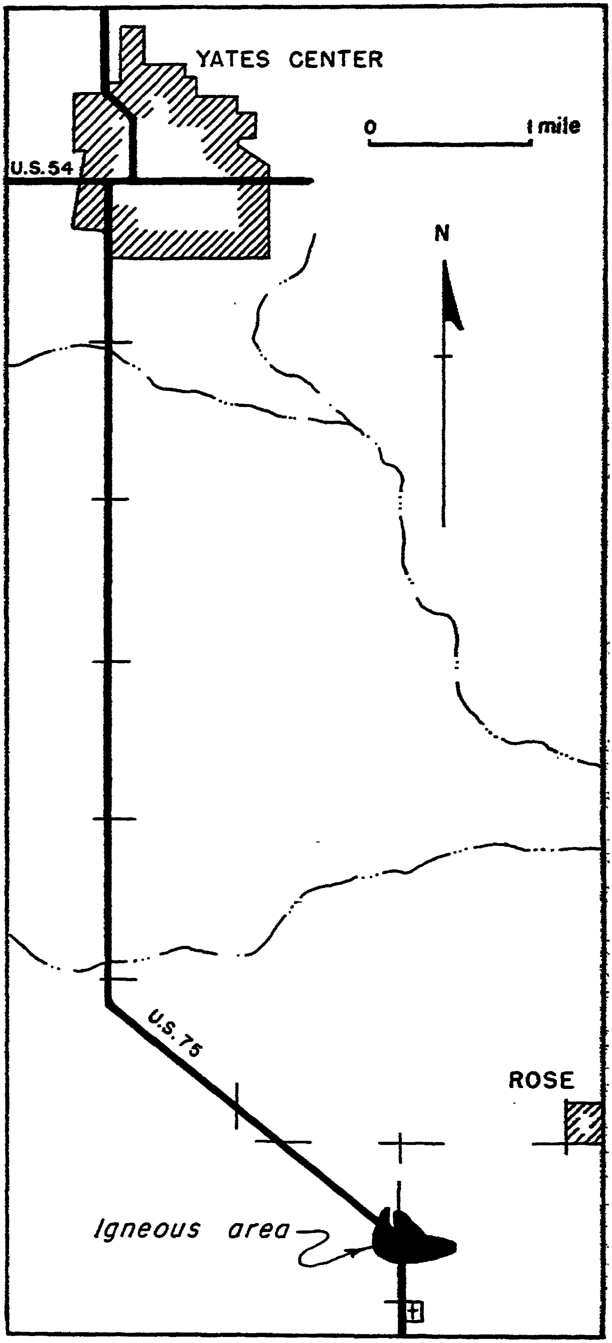


Fig. 14. Map showing location of igneous rock outcrop in Woodson County, Kansas.

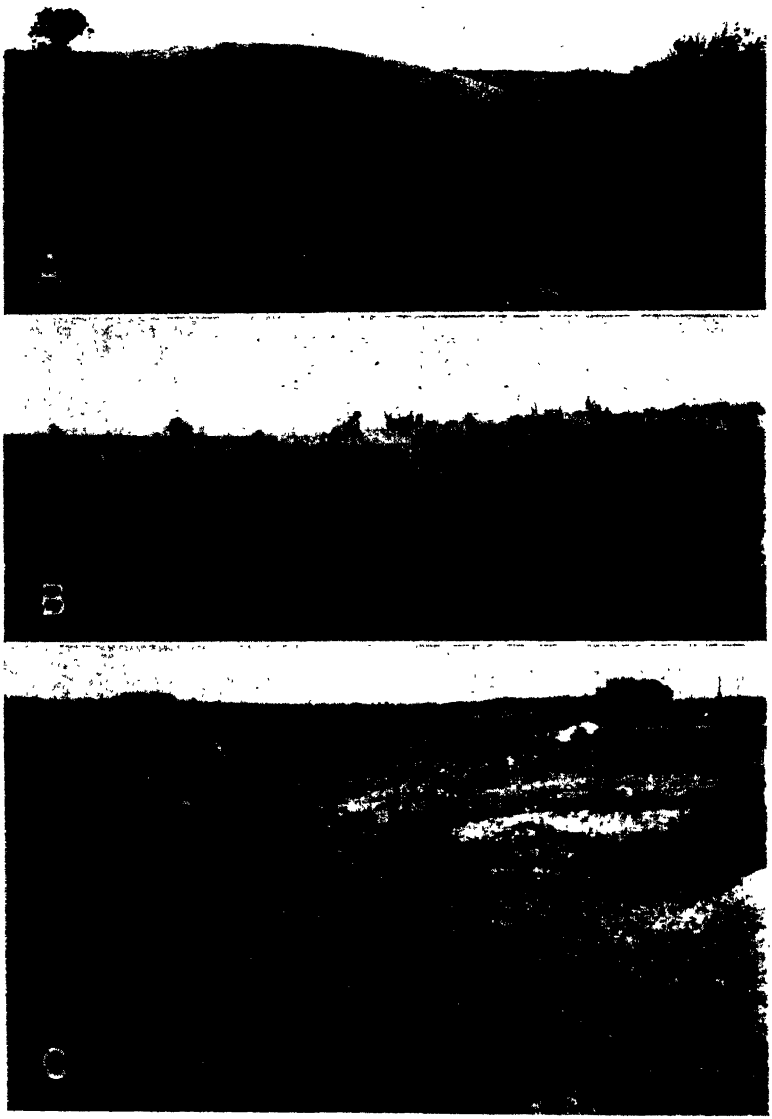


Fig. 15. Topographic expressions of the Riley County, Kansas, igneous intrusives: (A) Bala, (B) Leonardville, (C) Stockdale. The Leonardville intrusive forms a low terrace and is inconspicuous. The igneous rock may be seen in two small holes near the figure. The igneous rock at the Stockdale intrusive forms the floor of the creek bed.

surface formations are important as sources of oil and gas. Record of these rocks is to be had in the well logs of the numerous oil and gas wells that have been drilled in all parts of the State.

Underlying the sedimentary cover is the granite complex consisting of granite, quartzite, schist, and other rocks of Pre-Cambrian age, rocks that are approximately one-half billion years old. These ancient rocks lie everywhere beneath the surface of Kansas although at varying depths. Just east of Seneca in Nemaha County the granite is reached at a depth of about 590 feet, near Elmdale in Chase County at 1,890 feet, at El Dorado in Butler County at about 2,715 feet and in western Kansas the basement complex of rocks lies so deep that oil wells drilled to depths of 3,000 to more than 7,700 feet fail to penetrate the granite.

The floor of the Pre-Cambrian basement complex is by no means without relief (Fig. 16). A study of numerous logs of wells drilled for oil reveals that buried beneath the surface rocks in eastern Kansas is an impressive irregularity in the floor of the ancient granitic surface. This irregularity extends in a nearly straight line from Seneca in Nemaha County in the north to south of Winfield in western Cowley County in the south

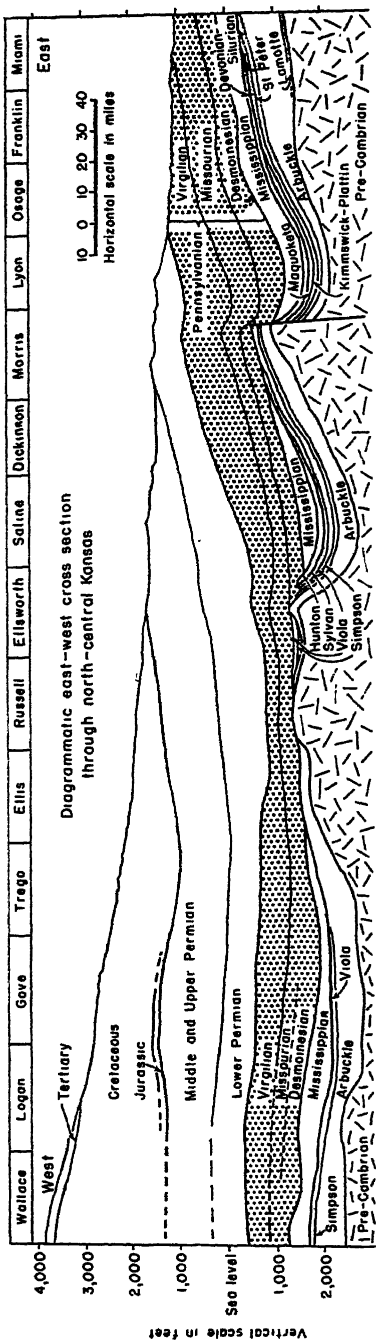


Fig. 16. Generalized cross-section of Kansas rocks. (Courtesy State Geological Survey of Kansas; Nixon, 1948; Jewett, Frye and Thompson, 1944)

(Fig. 18). This irregularity was formerly considered to be a buried mountain range to which Moore (1918, p. 105) gave the name Nemaha Mountains. It was also called the Buried Granite Ridge of Kansas. According to the detailed studies of Lee (1943, pp. 115-123) the buried irregularity, however, never appeared in the form of a mountain range which later became buried under sediments deposited in later geological times. Lee is of the opinion that at no time was the irregularity a prominent topographic feature but rather that as the area was uplifted, folded, and faulted sedimentation was sufficiently

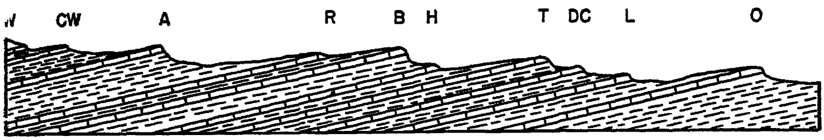


Fig. 17. Diagram showing shingle-like arrangement of Kansas strata in the Osage Cuesta physiographic unit. Letters refer to the names of the major rock formations.

rapid to keep the granitic mass from becoming no more than a low ridge above the surrounding county. The geologic history of the Nehama anticline as Lee (1943, pp. 115-123) called this eastern Kansas uplift is much more complex than is indicated here. The core of the Nehama anticline is composed of red to pink granite, quartz porphry, and chlorite schist. The structure is in the form of a big block or wedge tilted toward the west. The eastern slope is short and very steep, rising fairly abruptly from 1,500 to 2,500 feet above the surrounding granite floor. The western slope is much gentler and gradually merges after a distance of about 10 to 25 miles into the surrounding floor. In Nemaha County the top of the granitic irregularity lies 586 feet beneath the surface or at an elevation of 564 feet above sea level. Near Onaga in Pottawatomie County it is 960 feet beneath the surface or 165 feet above sea level. Near Elmdale in Chase County the irregularity is 502 feet below sea level and in the vicinity of Winfield in Cowley County its top is from 2,284 to 2,423 feet below sea level.

Structurally, the rock strata in Kansas are arranged in a more or less shingle-like manner (Fig. 17) and constitute regionally a very shallow downwarp or synclinal structure (Fig. 16). In the eastern one-half of the State the main inclination or dip of the strata is toward the west, whereas in the western one-half the rocks dip mainly in an easterly direction. There are many places, however, in which the strata dip to the east, north, and south. Seldom do the surface rocks dip more than 35 feet to the mile (Moore, Frye, and Jewett, 1944, p. 143). In addition to the numerous local and smaller structures, the regional synclinal structure is modified by

a number of major uplifts and basins, chief of which are the Nemaha and Central Kansas uplifts and the Forest City, Cherokee, Sedgwick, Salina, and Dodge City basins (Fig. 18). These uplifts and basins came into existence early in the Pennsylvanian period and except for some effects of regional tilting and differential subsidence conform to the subsurface structural organization of Kansas at the present time (Moore and Jewett, 1942, fig. 8, p. 486). In addition to the present structural elements

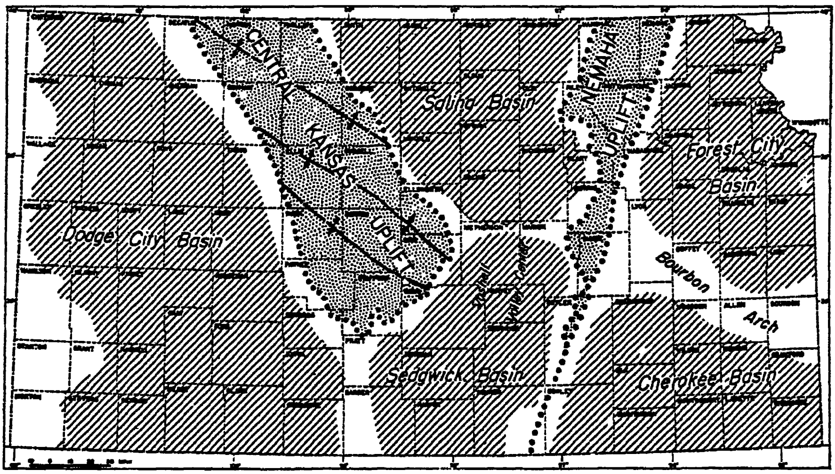


Fig. 18. Map showing major structural uplifts and basins in Kansas. (Courtesy State Geological Survey of Kansas; Moore and Jewett, 1942)

other and older structural features are recognized in the deeper subsurface strata. These structural elements are overlapped by the Pennsylvanian structures and include the Chautauqua arch, Ellis arch, North Kansas basin, and the Southwest Kansas basin (Fig. 19). These structural features are of paramount economic importance in finding and developing our oil and gas resources.

The geologic history of Kansas involves a span of more than 200 million years and a record of rocks totaling more than 10,000 feet. Outstanding events in the geologic history of the State may be summarized as follows.

(1). Before the deposition of the marine sedimentary rocks of early Paleozoic time, the surface of Kansas was irregular, being composed of igneous and metamorphic rocks and was subjected to erosion for a long time before it was buried under younger rocks.

(2). During Cambrian, Ordovician, Silurian, and Devonian times Kansas was repeatedly flooded by ocean waters.

(3). Before the deposition of early Mississippian or late Devonian rocks much of the surface of eastern Kansas had been reduced to an extensive peneplain,

(4). The peneplained surface was inundated by ocean waters of Mississippian time. The rocks laid down during this period were removed by late Mississippian or early Pennsylvanian erosion from a large area in eastern Kansas.

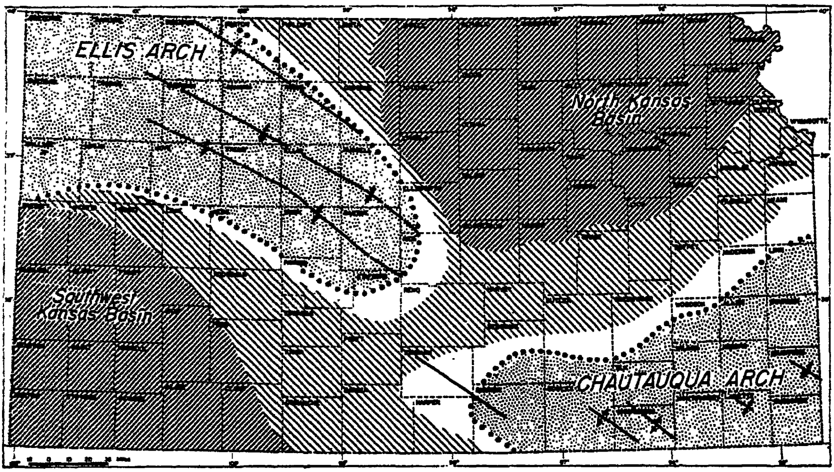


Fig. 19. Map showing the deeper structural elements in Kansas. (Courtesy State Geological Survey of Kansas; Moore and Jewett, 1942)

(5). During Pennsylvanian time Kansas was alternately submerged and elevated as is indicated by the cyclic sequence of marine strata and continental deposits many of which are coal bearing.

(6). Conditions in Kansas during early Permian time were in general similar to those that prevailed during the Pennsylvanian Period except that very little coal was formed. Later in the period climatic changes brought aridity to Kansas as is indicated by the extensive salt and gypsum deposits and the nonmarine red beds of the south-central part of the State.

(7) Following the formation of salt, gypsum, and red beds, Kansas underwent extensive erosion for the Cretaceous rocks overlie the beveled Permian beds that dip more steeply to the west than do the Cretaceous deposits. It was during this period that the great swimming and flying reptiles for which Kansas is world famous ruled the Kansas scene. Igneous intrusions probably also took place during the Cretaceous.

(8). On the withdrawal of the Cretaceous sea Kansas underwent a long period of erosion. Late in Tertiary time extensive deposits of gravel, sand, and silt were spread over all the State by streams coming from the west thus forming the plains character of the State.

(9). During Pleistocene time, wind and water greatly modified the plains character of Kansas. Volcanic ash was spread far and wide over the State. It was during this period also that northeastern Kansas was invaded twice by huge continental ice sheets, the Nebraskan and the Kansan continental ice sheets.

(10). Since glacial time, the surface of Kansas has undergone erosion by wind and water.

Physiography

Elevation and relief.—Physiographically Kansas is a plain. Its surface, however, is not everywhere flat, horizontal, and featureless, nor is it without relief. There are innumerable hills and picturesque valleys and at many places the slopes are not only steep but precipitous. In the western and southwestern part of the State many of the valleys are typical canyons with steep bare rock walls. The surface slopes gradually eastward at the rate of about 10 to 15 feet per mile. The highest spot (Fig. 20) in the State has an elevation of 4,135 feet above sea level and is located on the slightly rolling devide between Goose and Willow Creeks in sec. 12, T. 12 S., R. 43 W. in Wallace County. The lowest place (Fig. 20) in the State, slightly less than 700 feet above sea level, is about 3,435 feet lower than the highest point and is at a place where Verdigris River leaves Kansas to flow into Oklahoma, 3 miles south of Coffeyville in Montgomery County. Local relief varies greatly reaching a maximum of about 400 feet in areas bordering major stream courses. Elsewhere, local relief is seldom more than 100 feet. Some concept of the surface elevations of the State may be had from Table 11 which gives the elevations above sea level of the county seats, some of the larger towns and cities, and their airports, weather bureau stations, and railroad depots. Figure 20 shows the generalized topographic elevations of the State in terms of 500-foot intervals above sea level.

Major physiographic divisions.—On the basis of the major physical divisions of the United States, Kansas is part of the Interior Plains. The Interior Plains are made up of the Interior Low Plateaus, Central Lowland, and the Great Plains provinces of which only the latter two are represented in the State. In general, the eastern one-third of Kansas belongs to the Central Lowlands province, which in Kansas is divided by Kansas River into the Dissected Till Plains section on the north and the Osage Plains section on the south. The western two-thirds of the State lies in the Great

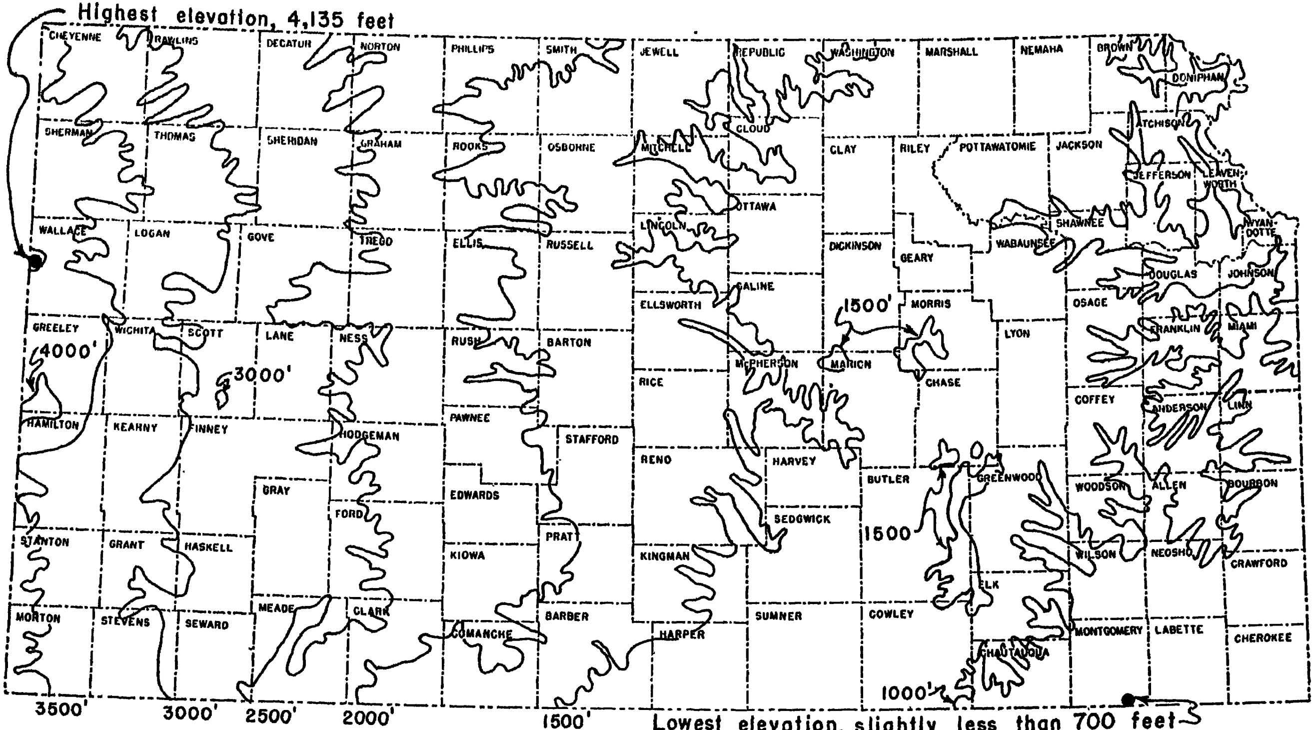


Fig. 20. Generalized topographic map of Kansas showing changes in elevation every 500 feet above sea level and showing locations of the highest and lowest spots in the State.

Plains province. In Kansas approximately the eastern one-third of this area constitutes the Dissected High Plains section and the remaining western part is known as the High Plains section*. The extreme southeastern corner of Kansas is included in the Springfield-Salem Plateaus sections of the Ozark Plateaus province of the Interior Highlands. A classification summarizing the major and minor physiographic divisions represented in Kansas together with a map showing their relationships to the

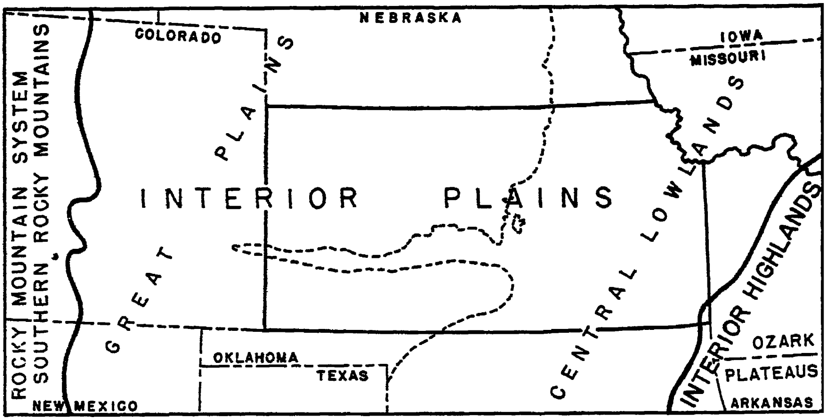


Fig. 21 Map showing Kansas in its relation to the major physiographic divisions of the central United States.

major physiographic divisions of the central part of the United States is presented in Table 12 and in Figures 21 and 22.

Detailed physiographic divisions.—The given classification of the physiographic divisions with the exception of the minor divisions (Table 12) and some slight modification of the sections is the accepted classification of physiographers and geologists of the United States and was prepared by Nevin M. Fenneman in cooperation with the Physiographic Committee of the U. S. Geological Survey. Such major physiographic divisions are naturally much generalized and cannot include all the detailed variations of topography that may exist in the various parts of a state. The

*Fenneman (1931, fig. 2, pp. 6, 7) divides the Great Plains province into the High Plains and Plains Border sections. As shown by Frye and Swineford (1949, pp. 80-81) there is no geologic and topographic basis for Fenneman's east border of his High Plains section. Frye and Swineford recommend that the border between the High Plains and Plains Border sections be placed at the Fort Hays limestone escarpment where originally it was located by Adams in 1901 (Adams, 1902, pp. 96, 102, fig. 2) and which here is adopted by me to be the logical line of division between the two sections. Furthermore, the term Plains Border in the present paper is abandoned for what seems to me a more appropriate name, the Dissected High plains section. According to Fenneman's classification the Plains Border is as much as 180 miles across, a distance approaching one-half of the width of the State and one hardly suggestive, therefore, of a border. Accepting the Fort Hays limestone escarpment as the east border of the High Plains section still leaves about 80 miles for the border section. For these reasons as well as the suggestion made by Frye and Swineford (1949, p. 80) that the term Plains Border section is no longer needed. I have named the former Plains Border section the Dissected High Plains section. The Great Plains province therefore consists of the High Plains and the Dissected High Plains sections. See Table 12.

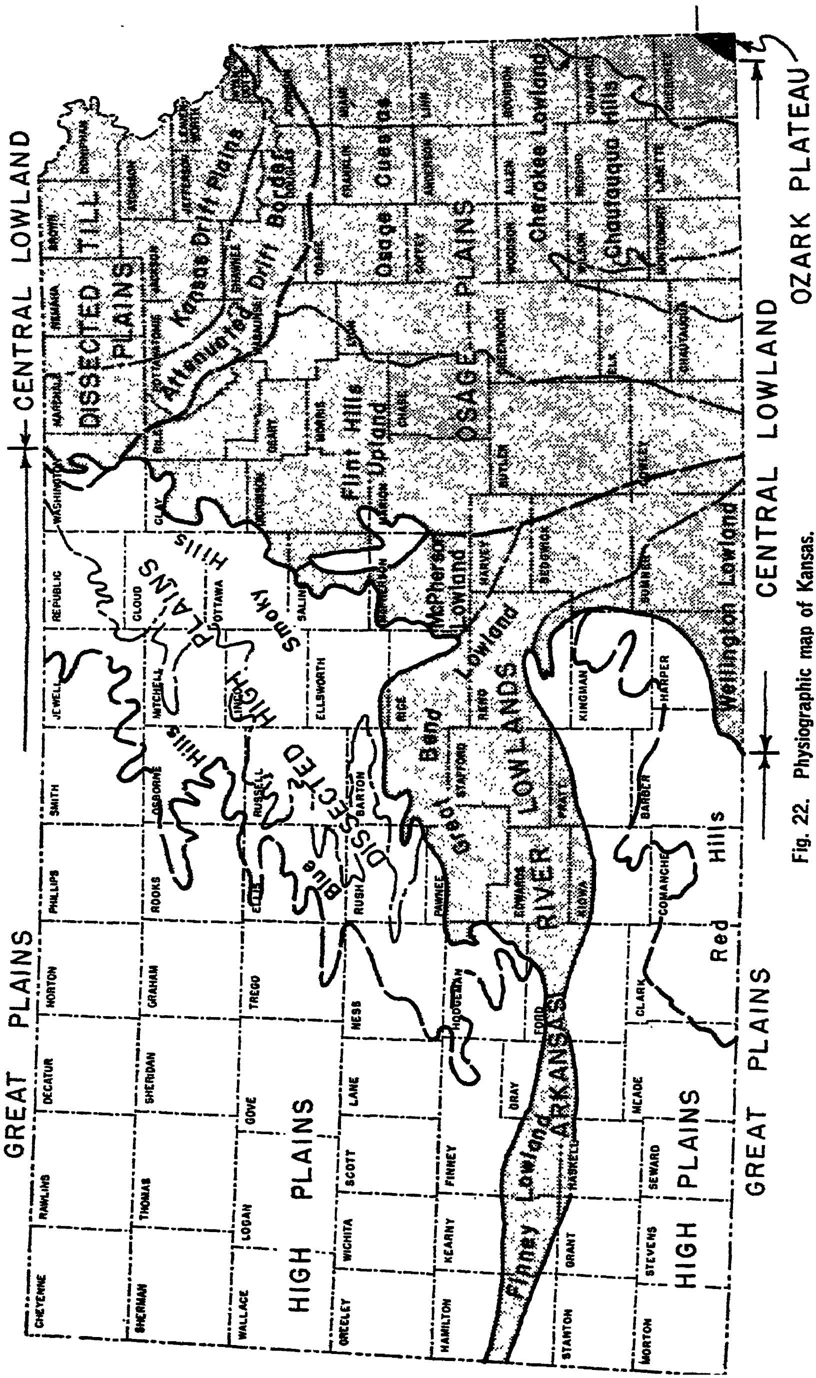


Fig. 22. Physiographic map of Kansas.

first attempt to describe in detail the physiographic features of Kansas was that of Adams in 1901 (1902, 1903). More recently Smith (1940, pp. 140-146), Latta (1944, pp. 19-26; 1948, pp. 15-20), McLaughlin (1943, pp. 19-21; 1946, pp. 16-21) and Frye (1942, pp. 33-35) have described in detail minor physiographic divisions of the southwestern part of the State. At the present time much of Kansas topography remains inadequately or entirely undescribed and unnamed. Geologic and physiographic field work done within recent years, notably that of Frye (1946, 1949) has demonstrated that even the major physiographic units as defined by Fenneman are in need of revision.

A brief description of the physiographic units of Kansas together with a map has been prepared by Moore (1930) and later by Webster (1931). Courtier (1934, Pl. 2) includes a physiographic map of the State in his report on the Physiography and Geology of South-Central Kansas. The physiographic units adopted for this paper are shown on Figure 22.

Table 11. Elevations of Kansas County Seats and Prominent Cities.

City	County	Railroad Stations*					General**	Weather Bureau Station†	Airports††
		A.T.S.F.	U.P.	C.R.I.P.	M.P.	Others			
Abilene	Dickinson	1,151	......	1,152	......	......	1,150	......	1,100M
Alma	Wabaunsee	1,053	......	1,057	......	......	1,080	......	......
Anthony	Harper	1,343	......	1,340	1,331	1,075	1,340	1,329	1,339M
Arkansas City	Cowley	1,073	......	......	......	......	..	1,073	1,067C
Ashland	Clark	1,950	......	......	......	......	1,970	1,979	1,940M
Atchison	Atchison	795	......	......	......	......	900	973	1,000C
Atwood	Rawlins	......	......	......	......	2,843	2,843	2,894	2,900M
Augusta	Butler	1,214	......	......	......	1,227	..	1,287	1,280M
Baxter Springs	Cherokee	......	......	......	......	......	842	......	......
Belleville	Republic	......	1,543	1,514	......	......	1,530	1,512	1,520C
Beloit	Mitchell	......	1,382	......	1,378	......	1,400	1,383	1,420M
Burlington	Coffey	1,035	......	......	......	1,033	1,030	1,010	1,035C
Caldwell	Sumner	......	......	1,107	......	......	......	......	1,140M
Caney	Montgomery	737	......	......	741	......	......	......	......
Cedar Vale	Chautauqua	914	......	......	924	......	......	......	1,000C
Chanute	Neosho	942	......	......	......	910	......	981	980M
Cherryvale	Montgomery	837	......	......	......	836	......	......	......
Cimarron	Gray	2,625	......	......	......	......	2,650	2,625	......
Clay Center	Clay	......	1,200	......	......	......	1,220	1,203	1,200M
Coffeyville	Montgomery	......	......	......	......	730	......	744	743M
Colby	Thomas	......	3,150	3,138	......	......	3,141	3,138	3,125C
Coldwater	Comanche	2,089	......	......	......	......	2,100	2,112	2,100C
Columbus	Cherokee	......	......	......	......	893	910	......	900C
Concordia	Cloud	1,363	1,363	......	1,365	......	1,400	1,394	1,510MC
Cottonwood Falls	Chase	1,191	......	......	......	......	1,200	1,191	......
Council Grove	Morris	......	......	......	1,234	......	1,250	1,234	1,380M
Dighton	Lane	2,759	......	......	......	......	2,759	......	2,760C
Dodge City	Ford	2,486	......	2,480	......	......	2,500	2,592	2,594M
El Dorado	Butler	1,285	......	......	1,285	......	1,300	1,291	1,400M
Elkhart	Morton	......	......	......	......	......	......	3,595	3,500M
Ellsworth	Ellsworth	......	1,537	......	......	1,534	1,540	1,537	1,630M
Emporia	Lyon	1,140	......	......	......	1,138	1,150	1,138	1,200M
Erie	Neosho	909	......	......	......	896	880	......	......
Eureka	Greenwood	1,075	......	......	......	......	1,050	......	1,100C
Florence	Marion	1,270	......	......	......	......	......	1,269	1,320C

Table 11 (Continued). Elevations of Kansas County Seats and Prominent Cities.

City	County	Railroad Stations*					General**	Weather Bureau Station†	Airports††
		A.T.S.F.	U.P.	C.R.I.P.	M.P.	Others			
Fort Scott	Bourbon					800	800	857	900M
Fredonia	Wilson	866					900	994	880M
Galena	Cherokee					874			
Garden City	Finney	2,829					2,950	2,836	2,894M
Garnett	Anderson	1,047					1,050	1,046	1,060M
Girard	Crawford					993	980		950C
Gove	Gove								
Goodland	Sherman			3,687			3,680	3,688	3,689M
Great Bend	Barton	1,848					1,840	1,863	1,883M
Greensburg	Kiowa			2,244			2,240	2,235	2,230M
Hays	Ellis		1,999				2,000	2,000	2,020M
Herington	Dickinson			1,324				1,328	1,450C
Hiawatha	Brown					1,095	1,050		1,100C
Hill City	Graham		2,134				2,200	2,134	2,200M
Hoisington	Barton				1,816			1,860	1,870M
Holton	Jackson			1,043			1,070	1,043	
Horton	Brown			1,015				1,029	
Howard	Elk	1,008					1,000	1,112	
Hoxie	Sheridan		2,654				2,654	2,700	2,665M
Hugoton	Stevens						3,107	3,100	3,107C
Humboldt	Allen	961							
Hutchinson	Reno	1,528		1,530			1,530	1,535	1,542M
Independence	Montgomery	798					800	800	820M
Iola	Allen	957			965		1,040	963	1,020M
Jetmore	Hodgeman	2,261					2,300	2,268	2,465M
Johnson	Stanton						3,330	3,276	3,330C
Junction City	Geary		1,078				1,070	1,078	1,260C
Kansas City	Wyandotte				771		740	741	746M
Kingman	Kingman	1,506			1,500		1,500	1,504	1,600M
Kinsley	Edwards	2,172					2,160	2,159	2,150C
Lakin	Kearny	2,998					3,000	2,993	3,050C
Larned	Pawnee	1,995			2,023		2,000	2,090	2,012M
Lawrence	Douglas	825	819				840	867	832M
Leavenworth	Leavenworth					765	800	913	
Lebanon	Smith			1,816					1,820C
Leoti	Wichita				3,297		3,297	3,300	3,230C
Liberal	Seward			2,839			2,851	2,843	2,888M
Lincoln	Lincoln						1,420	1,374	1,420M
Lindsborg	McPherson			1,332				1,333	
Lyndon	Osage	1,010			1,111		1,050	1,006	
Lyons	Rice					1,696	1,690	1,696	1,950M
Madison	Greenwood	1,070							
Manhattan	Riley	1,002					1,030	1,073	1,050M
Mankato	Jewell			1,787			1,740		1,840M
Marion	Marion	1,301		1,301		1,154	1,300	1,310	1,370M
Marysville	Marshall						1,150		1,240M
McPherson	McPherson	1,490	1,495	1,494			1,480	1,495	1,500M
Meade	Meade			2,503			2,470		2,530M
Medicine Lodge	Barber	1,468					1,500	1,475	1,530C
Minneapolis	Ottawa	1,254	1,255				1,300	1,259	1,250C
Mound City	Linn						900		
Neodesha	Wilson					800			
Ness City	Ness	2,258					2,220	2,260	2,245C
Newton	Harvey	1,445					1,470	1,454	1,527M
Norton	Norton	2,270				2,275	2,260	2,340	2,365M
Oberlin	Decatur					2,561	2,561	2,539	2,684M
Olathe	Johnson	1,023				1,055	1,000	1,032	1,000C
Osage City	Osage	1,077			1,084			1,081	
Osborne	Osborne	1,557					1,560		1,565M
Oskaloosa	Jefferson				1,020	991	1,070		

Table 11 (Continued). Elevations of Kansas County Seats and Prominent Cities.

City	County	Railroad Stations*					Gen-eral**	Weather Bureau Station†	Air-ports††
		A.T.S.F.	U.P.	C.R.I.P.	M.P.	Others			
Osawatomie	Miami	--	--	--	--	--	--	861	960M
Oswego	Labette	--	--	--	--	--	900	899	--
Ottawa	Franklin	847	--	--	--	--	900	891	975M
Paola	Miami	--	--	--	--	--	850	865	960M
Parsons	Labette	--	--	--	--	--	--	898	870M
Peabody	Marion	1,351	--	1,356	--	--	--	--	--
Phillipsburg	Phillips	--	--	1,939	--	--	1,939	1,939	1,882M
Pittsburg	Crawford	--	--	--	--	932	934	934	948M
Pratt	Pratt	1,887	--	--	--	--	1,880	1,880	1,940M
Richfield	Morton	--	--	--	--	--	3,700	3,700	--
Russell	Russell	--	1,828	--	--	--	1,820	1,834	1,860M
Russell Springs	Logan	--	--	--	--	--	--	--	--
Sabetha	Nemaha	--	--	1,300	--	--	--	--	--
Salina	Saline	--	1,226	1,226	1,216	--	1,220	1,227	1,275M
Scott City	Scott	2,971	--	--	--	--	2,971	2,971	2,980M
Sedan	Chautauqua	--	--	--	841	--	850	834	850C
Seneca	Nemaha	--	--	--	--	1,150	1,200	--	1,250M
Sharon Springs	Wallace	--	3,456	--	--	--	3,442	3,440	3,500C
Smith Center	Smith	--	--	1,804	--	--	1,810	1,800	1,806M
St. Francis	Cheyenne	--	--	--	--	3,291	3,291	3,288	3,400M
St. John	Stafford	1,908	--	--	--	--	1,900	--	1,885C
Sterling	Rice	1,637	--	--	--	--	--	--	1,630C
Stockton	Rooks	--	--	--	1,775	--	1,820	1,775	--
Strong City	Chase	1,174	--	--	--	--	--	--	--
Sublette	Haskell	--	--	--	--	--	2,920	2,911	--
Syracuse	Hamilton	3,229	--	--	--	--	3,230	3,227	3,320M
Topeka	Shawnee	889	880	892	--	--	900	926	879M
Tribune	Greeley	--	--	--	3,543	--	3,543	3,612	3,550C
Troy	Doniphan	--	--	--	--	1,093	950	--	--
Ulysses	Grant	--	--	--	--	--	3,045	3,050	3,050C
Wakeeney	Trego	--	2,456	--	--	--	2,450	2,456	--
Washington	Washington	--	--	--	1,310	1,335	1,310	--	1,290M
Wellington	Sumner	1,213	--	1,189	--	--	1,200	1,228	1,290C
Westmoreland	Pottawatomie	--	--	--	--	--	1,270	1,250	--
Wichita	Sedgwick	1,312	--	1,291	1,295	--	1,300	1,372	1,370M
Winfield	Cowley	1,114	--	--	1,117	1,120	1,150	1,202	1,200M
Yates Center	Woodson	1,099	--	--	1,114	--	1,100	1,099	--

*Gannett, Henry, 1906, Dictionary of Altitudes in the United States: U.S. Geol. Survey, Bull. 274, Fourth Edition, pp. 333-360. Column headed "Others" refers to railroad stations in towns other than those listed.

**Map, Kansas the Sunflower State, Scenic and Historic Kansas, issued by Kansas Industrial Development Commission and Kansas State Highway Commission.

†Flora, Snowden, D., 1948, Climate of Kansas: Kansas State Board of Agriculture, vol. 67, no. 285, pp. 1-320.

††Kansas Airport Directory, 1948: Kansas Industrial Development Commission, pp. 1-72. M=Municipal airport, C=Commercial airport.

The minor subdivisions of Kansas generally recognized and accepted are indicated in Table 12.

Ozark Plateau Province

Extension of Springfield-Salem Plateau section.—Only a very small portion of the Ozark plateau province extends into Kansas (Figs. 21, 22). The Kansas portion which is an extension of the Springfield Plateau section of Missouri is confined to the extreme southeastern corner of the State in Cherokee County. Spring River marks its approximate western

Table 12. Classification of major and minor physiographic divisions of Kansas.

Major Division	Province	Section	Minor Division
Interior Plains	Great Plains	High Plains	
		Dissected High Plains*	Smoky Hills Blue Hills Red Hills
	Central Lowland	Dissected Till Plains	Kansas Drift Plains* Attenuated Drift Border*
		Osage Plains	Flint Hills Upland Osage Cuestas* Chautauqua Hills* Cherokee Lowlands
		Arkansas River Lowlands*	Finney Lowland* Great Bend Lowland* McPherson Lowland* Wellington Lowland*
Interior Highlands	Ozark Plateaus	Springfield-Salem Plateaus	

*Newly introduced or modified terms.

limits with Baxter Springs in the southwest corner. Galena is also included in the section. The area, no more than 50 square miles in extent, constitutes the border of a westward-dipping structural plain which is underlain by 50 feet of the "Warsaw" and Keokuk limestones of Mississippian age. This portion of the State is essentially flat with sufficient slope, however, to effect good drainage. The relief averages less than 60 feet. The section under discussion is part of the Tri-State lead and zinc district which is the largest zinc district and the third largest lead-producing district in the United States.

Central Lowland Province

In Kansas the Central Lowland province is divided into the Osage Plains, Disseted Till Plains, and the Arkansas River Lowlands* (Fig. 22). Kansas River separates the Dissected Till Plains from the Osage Plains, the former lying north of the river and the latter south. The Arkansas River Lowland, and the Wellington Lowland, are all in the Arkansas River Valley or adjacent to it.

Osage Plains

The Osage Plains (Fig. 22) as here defined include the Cherokee Lowland in the southeastern part of the State, the Chautauqua Hills south of Neosho River, the Osage Cuestas including most of eastern Kansas

*It is here proposed to establish the Arkansas River Lowlands section as the third unit of the Central Lowland province. Adams (1902, pp. 93, 96, figs. 1-2; 1903, pp. 110, 113) originally included part of the area in his Great Bend Prairie and Oklahoma Prairie divisions of the Prairie Plains region; Fenneman (1931, pp. 27-28), on the other hand, included part of the area in his Great Plains province, and part in his Central Lowland province. The Arkansas River Lowlands is here subdivided into the Finney Lowland, Great Bend Lowland (Great Bend Prairie of Adams), the McPherson Lowland (part of the Great Bend Prairie of Adams), and the Wellington Lowland (part of the Oklahoma Prairie and Great Bend Prairie of Adams). The Finney, Great Bend, McPherson, and Wellington Lowlands are all relatively low-lying topographic areas bordering or adjacent to Arkansas River and on the basis of position are more closely related to the Central Lowland province than they are to the High Plains province.

south of Kansas River, and the Flint Hills Upland which forms the west border of the section.

Cherokee Lowland.—The Cherokee Lowland comprises about 1,000 square miles in Bourbon, Crawford, Cherokee, and Labette Counties (Fig. 22). Fort Scott, Pittsburg, and Columbus are within the lowland whereas Oswego and Baxter Springs are at its borders. Cherokee, Weir City, Mineral, Sherman, and Chetopa are towns also located in the unit. The Cherokee Lowland is an erosional plain whose surface slopes to the west at an average rate of about 10 feet per mile (Abernathy, 1946, p. 129). It is developed upon the weak shales and sandstones of the Cherokee shale which in Kansas ranges in thickness at the outcrop from 400 to 600 feet, averaging about 450 feet. The Cherokee shale is the lowermost unit of the Pennsylvanian System of rocks in the State. The total relief of this physiographic unit is about 250 feet. The surface is gently undulating except for a few erosional remnants capped by resistant standstone of which the broad, flat-topped mesa-like Timbered Hills is the largest. The Timbered Hills rise more than 80 feet above the level of the surrounding country and are between 7 and 8 miles due north of Baxter Springs in Cherokee County. The valleys are wide, shallow, and flat-bottomed. Neosho and Spring Rivers and Drywood Creek with their tributaries drain the Cherokee Lowland which constitutes the largest area of coal mining in the State.

Chautauqua Hills.—The Chautauqua Hills include a triangular belt approximately 10 miles wide extending from about Yates Center in Woodson County southward to the state line in Montgomery and Chautauqua Counties (Fig. 22). The Chautauqua Hills are developed chiefly in the thick sandstones of the Douglas group which farther to the north are replaced by shales and which there, because of their position between the limestones, produce escarpments. As a result of erosion in the sandstone belt the surface has been dissected into a series or range of low hills which are characteristically covered by a growth of jack-oaks. The entire division, named by Adams (1899, p. 61) the Chautauqua Sandstone Hills, is intersected by many deep-valleyed small streams. The Verdigris, Fall, and Elk Rivers cross the area in narrow valleys walled in by bluffs which show thick sandstones as their protecting element. The relief of the Chautauqua Hills is nowhere greater than 250 feet. About 7 miles south of Yates Center along the east border of the Chautauqua Hills and extending eastward from sec. 13, 2. 26 S., R. 15 E. to the edge of the township is the Rose Dome occurrence of the granite and the Silver City quartzite mentioned elsewhere in these pages. The sandstones of the Douglas group extend northeastward to the vicinity of Leavenworth on Missouri River

and give rise to sandstone-capped hills which, however, are much less conspicuous topographic features than those south of Neosho River. Jewett (1941, p. 17) believes that the northward extension of the sandstone-capped hills might well be included in the Chautauqua Hills physiographic unit.

Yates Center is the chief city in the Chautauqua Hills division. Toronto, Fall River, Elk River, Sedan, and Chautauqua mark its west border whereas Caney and Elk City define its east border.

Osage Cuestas.—The Osage Cuestas* (Fig. 22), or the Osage Prairie of Adams, comprise essentially all of eastern Kansas south of Kansas River and as far west as Manhattan in Riley County, Cottonwood Falls in Chase County, and Cedar Vale in Chautauqua County. In general, the Osage Cuestas consist of a series of northeast—southwest irregularly trending east-facing escarpments between which are flat to gently rolling plains (Fig. 17 and 24). The underlying strata are made up of unequally resistant alternating hard and soft Pennsylvanian formations of limestone and shale which are gently inclined to the west and northwest. The cuestas are due to differential erosion in these alternating hard and soft gently westward-dipping shales and limestones. Each cuesta consists of a steep bold east-facing front or escarpment and a gentler inclined surface or vale sloping in the direction of the dip of the strata (Fig. 17). The

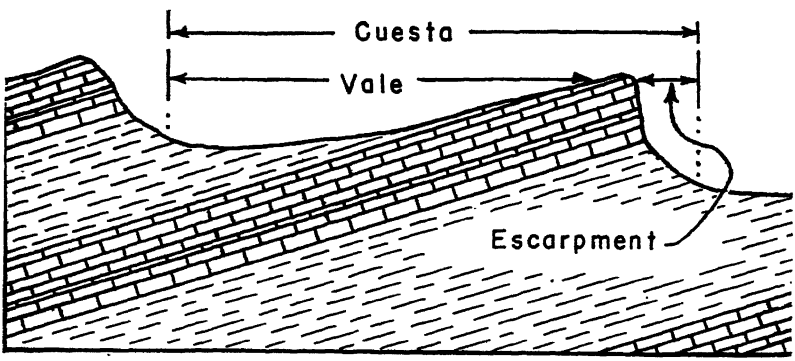


Fig. 23. Diagram showing the profile and elements of a cuesta.

*The name Osage Cuestas is here proposed for Adams' (1902, pp. 94-96; 1903, pp. 113, 115) Osage Prairie and the need for a name for the unnamed part of Fenneman's Osage Plains section. Fenneman (1938, pp. 605-622) in describing the Osage Plains section recognizes in Kansas the Flint Hills, the Chautauqua Hills, and the Cherokee Lowland and describes each as distinctive features of the Osage Plains section. It follows, therefore, that the remaining portion of the section should be designated by a minor division physiographic name. The designation Osage Cuestas is descriptive of the area since the topography is characterized by a series of 18 cuestas. A cuesta is an erosional topographic feature which is developed in slightly tilted alternating hard and soft sedimentary rocks. It consists of an escarpment and a vale. Martin (1916, p. 42) describes a cuesta as "an upland with a short steep descent, or escarpment, on one side and a long, gentle slope on the other. The gentle slope usually corresponds to the inclination or dip of slightly deformed sedimentary rocks" (Fig. 23). Similar topographic features developed in steeply dipping alternating hard and soft sedimentary rocks are hogbacks.

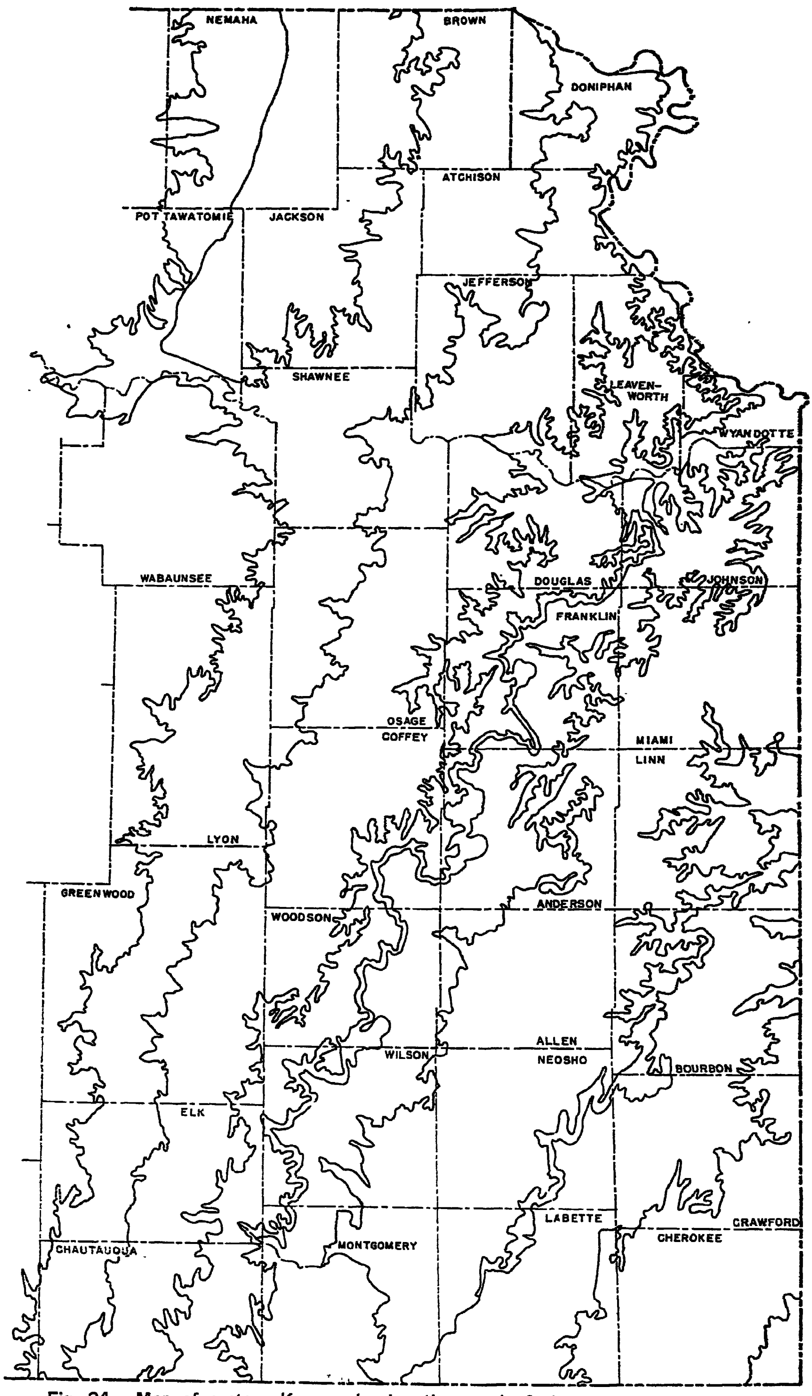


Fig. 24. Map of eastern Kansas showing the trend of the major cuesta escarpments. (After Moore, 1949)

crest of each escarpment is capped by a resistant limestone usually underlain by weak shales or sandstones. The dip-slope surface or gentler slope of the cuesta although controlled largely by the resistant limestone is nevertheless mostly developed in the weaker shales or sandstones. The escarpment fronts range in height from 50 feet or less to more than 200 feet. Wherever the escarpments are bold and the underlying shale is thick, mounds commonly exist to the southeast of and parallel to the escarpment proper. Some of the mounds like Table Mound northwest of Independence have broad, flat tops and are of large size. Others are rounded and still others

Fig. 25. Cuesta topography. (A) Oread escarpment between Lawrence and Tonganoxie; (B) escarpment south of Maple Hill, rocks lower Permian

have the form of a frustrum of a cone as those in the vicinity of Cherryvale and Mound Valley. At least 18 escarpments (Fig. 24) characterize the Osage Cuesta topography (Fig. 25). Kansas, Marais des Cygnes, Neosho and Verdigris Rivers flow in a general east and southeast direction transverse to the direction of the escarpments and against the dip of the rock formations. The major streams flow in valleys from one to several

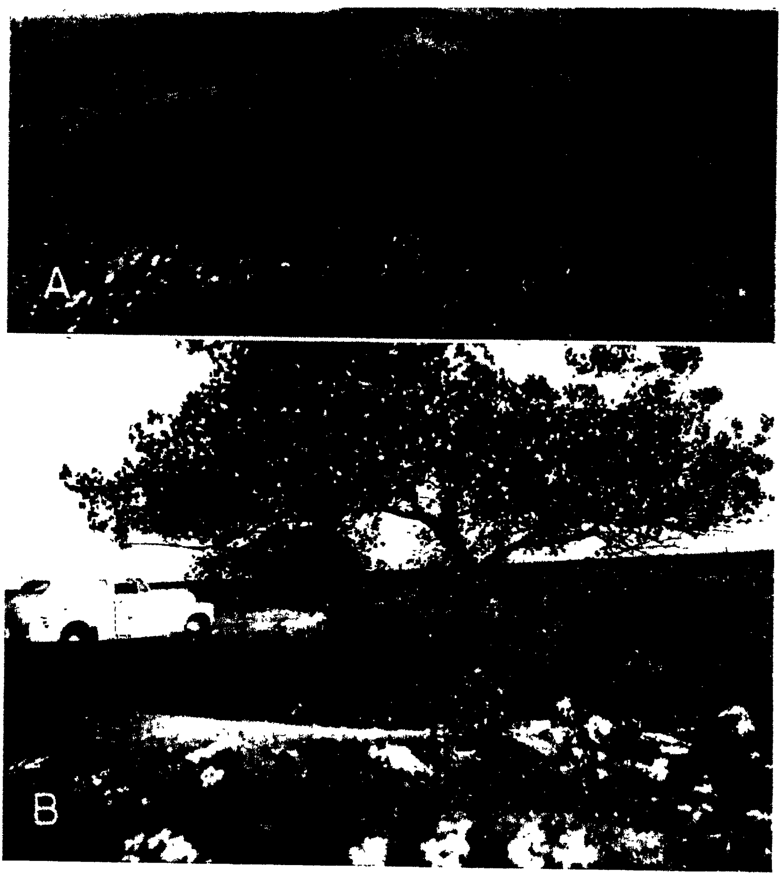


Fig. 26. Flint Hills topography. (A) Flint Hills escarpment south of Manhattan along highway K-13, Geary County. (B) Sink hole in upland, northwest corner of Morris County.

miles wide with their flood plains from 100 to 200 feet below the cuesta summits.

The Osage Cuestas division is the most thickly populated portion in Kansas. Burlingame, Burington, Cedar Vale, Chanute, Cherryvale, Coffeyville, Cottonwood Falls, Council Grove, Emporia, Eureka, Garnett, Howard, Independence, Iola, Manhattan, Mound City, Neodesha, Olathe, Osage City, Paola and Parsons, are located in this physiographic section. Coal, oil and gas, asphalt rock, cement, and building stone are produced in the section. Agriculturally, general farming is the chief industry.

Flint Hills Upland.—The Flint Hills Upland (Fig. 22) constitutes a north-south trending topographic unit that extends entirely across the State and whose limits are defined by the outcrop of flint-bearing Permian strata. Excluded from this upland is that portion of country underlain by Permian rocks that lies west of the Sixth Principal Meridian or a north-south line passing approximately through Wichita. The surface features, the structure and erosional history of the upland are similar to that of the lower Osage Cuestas underlain by Pennsylvanian strata from which it is separated by a very prominent rocky escarpment several hundred feet high. It is this highly dissected east-facing escarpment with its terraced rocky slopes that makes possible the separation of the Flint Hills Upland from the lower or east division of the Osage Plains section. This eastern border of the upland is probably the most rugged surface feature of Kansas and one of the most scenic portions of the State (Fig. 26A). Formerly it was called the Kansas Mountains and later the Flint Hills (Bass, 1929, p. 14). The Flint Hills are a range of hills about 20 miles wide extending from Marshall County in the north to Cowley County in the south and have a relief of about 350 feet (Jewett, 1941, p. 17). The eastward-facing steep slope of the escarpment is not everywhere one great step but is more commonly made up of two or three closely spaced rock benches with the intervening slopes rising with steep gradients to the highest bench which everywhere forms the broad upland of the Flint Hills Upland. The scarp slope is considerably dissected. The streams in the Flint Hills have deep, precipitous channels lined with outcropping rock ledges. Their beds, strewn with angular fragments of limestone and flint (chert)*, are incised in narrow boxlike channels where cut in the flint-bearing rocks but at points where cut in the weaker shales the valleys immediately open out and the valley slopes are much gentler. The valleys of the east or west-flowing streams are characteristically asymmetrical with the steeper slopes

*Flint and chert are varieties of quartz, very hard so that they cannot be scratched with a knife and which break with a shell-like or conchoidal fracture. Flint is dark in color whereas chert is usually of some lighter shade of gray or brown. For all general purposes, chert and flint may be considered synonyms.

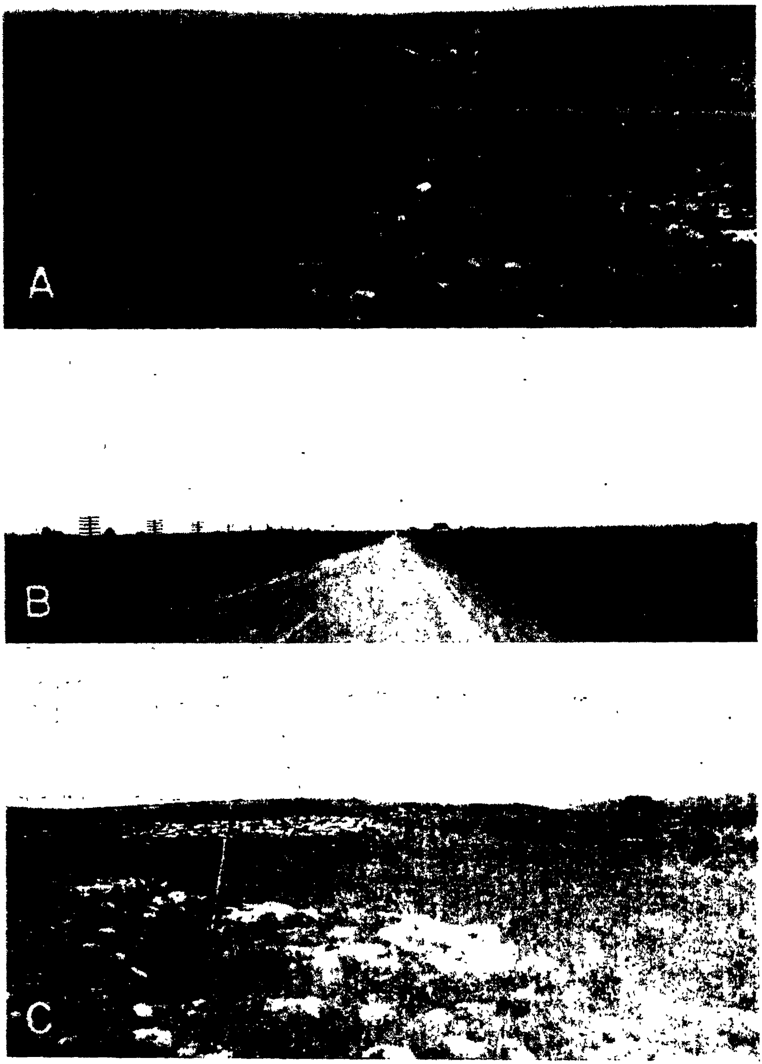


Fig. 27. Flint Hills topography. (A) Dissected Flint Hills Upland, southern Geary County. (B) Flat topography 5 miles east of Herington U. S. Highway 50 N, Morris County. (C) Rocky character of Flint Hills Upland, K-10 near Alta Vista, Wabaunsee County.

on the south side of the valleys. In Cowley County, Grouse Creek, a north-south flowing left-handed tributary of Arkansas River divides the Flint Hills into two ridges, the easternmost one of which is known as the Big Flint Hills, and the western one as the Little Flint Hills (Adams, 1903, p. 119). North of Kansas River, the Flint Hills diminish in height and become a less conspicuous topographic feature than they are south of the river. As this part of the Flint Hills has been glaciated as evidenced by scattered erratics and till deposits it is included in the Attenuated Drift Border unit of the Dissected Till Plains section.

The surface of the Flint Hills Upland is gently rolling and merges on the west with the smooth and gentle slope which trends toward the Arkansas River Valley (Fig. 27). At places, the upland surface is pitted with sink holes (Fig. 26B). The summit elevations for most of the Flint Hills Upland south of central Kansas is between 1,500 and 1,600 feet (Fenneman, 1938, p. 615). Flint Ridge, Summit, Beaumont, and Grand Summit are names of towns that suggest the general topographic expression of this unit. A slope to the east of 400 to 500 feet in 10 to 15 miles is common. Kansas River is the only stream that crosses the upland. Kansas River formed by the junction of Smoky Hill and Republican Rivers in the midst of the upland flows in a well-defined, rock-walled, terraced valley from 2 to 3 miles wide and from 150 to 200 feet deep. Other streams draining the Upland include the Elk, Big Caney, Verdigris, Neosho, Cottonwood, Marais des Cygnes, and Big and Little Blue Rivers. The divides between the streams rise about 300 feet above the valley floors.

The Flint Hills Upland, including the Flint Hills escarpment, derives its name from the large amount of flint or chert found over its surface. Nearly all the limestones of the unit contain some flint and some of the beds are composed entirely of this siliceous material. Since the flint or chert is practically insoluble, it is very resistant to weathering and erosion and tends to accumulate as rocky fragments strewn over the surface affording a protecting cover for the weaker underlying strata. As a result of this protecting cover, broad benches are developed which usually are characterized by a scanty growth of vegetation. It is not to be inferred, however, that the Flint Hills Upland owes its topographic expression solely to the presence of the flint or chert contained in the Permian strata of the unit. The flint has merely accentuated the resistance of the hard layers and likewise magnified the results of erosion (Bass, 1929, p. 14). The height of the Flint Hills is to be attributed to the presence of a few hundred feet of soft strata beneath a few beds that hold benches under conditions of weathering to which they are subjected (Jewett, 1941, p. 19). According to Jewett (1941, p. 19) the flinty material in the northern part

of the upland is readily weathered into steep slopes and rounded knobs.

The Flint Hills also served well the aborigines for on the summit of the Hills are found their ancient quarries from which the flint was obtained to fashion their arrowheads, spears, knives, and other artifacts (Mead, 1901, p. 207). The Flint Hills Upland south of Kansas River comprising about 16,000 square miles constitutes one of the finest grazing areas in the State if not elsewhere in the United States. According to J. C. Mohler, Secretary of the Kansas State Board of Agriculture, the "Bluestem Region" as he calls this physiographic unit, grazes from 300,000 to 400,000 head of Texas and New Mexico cattle every year. The name "Bluestem region" is well suited to this topographic unit agriculturally, because of the excellent stand of blue-stem grass which flourishes there. Physiographically and geologically, however, the Flint Hills Upland is a more appropriate name for the unit. The Flint Hills Upland is also important for the location of some of the more important oil and gas fields of eastern Kansas. Wichita, El Dorado, Winfield, Eureka, Cottonwood Falls, Council Grove, Junction City, Manhattan, Herington, Marion, Abilene, Madison, Clay Center, Arkansas City, and Newton are located in this physiographic unit.

Dissected Till Plains

Kansas Drift Plain.—The Dissected Plains (Fig. 22) lie north of Kansas River and are in reality a northward extension of the Osage Plains. The underlying bedrock of both sections is identical. The Dissected Till Plains differ from the Osage Plains in that the former have been glaciated whereas the latter have not. As a result of at least two ice invasions, a covering of drift either conceals or mantles much of the cuesta-type of topography prevalent in the Osage Cuestas unit to the south. Typical rock-controlled topography is absent in the Dissected Till Plains section except near its southern margin close to the valley of Kansas River and on the west in the territory paralleling Big Blue River in Pottawatomie, Marshall, Washington, and Riley Counties. This portion of the unit might well be designated the Attenuated Drift Border unit and is thus described separately below. In most of the remainder of this unit the topography is an erosional drift-controlled surface which in general may be described as gently undulating. Interstream areas or divides remote from major drainage lines are smooth, broad, and well rounded and are the remnants of the original uneroded ground moraine topography left on the retreat of the ice. Approaching the larger stream courses the country becomes more dissected, the surface is all reduced to gentle slopes, and the valleys are wide and open. Adjacent to the larger streams the country is highly dissected into a rough and hilly region. The river bluffs in many

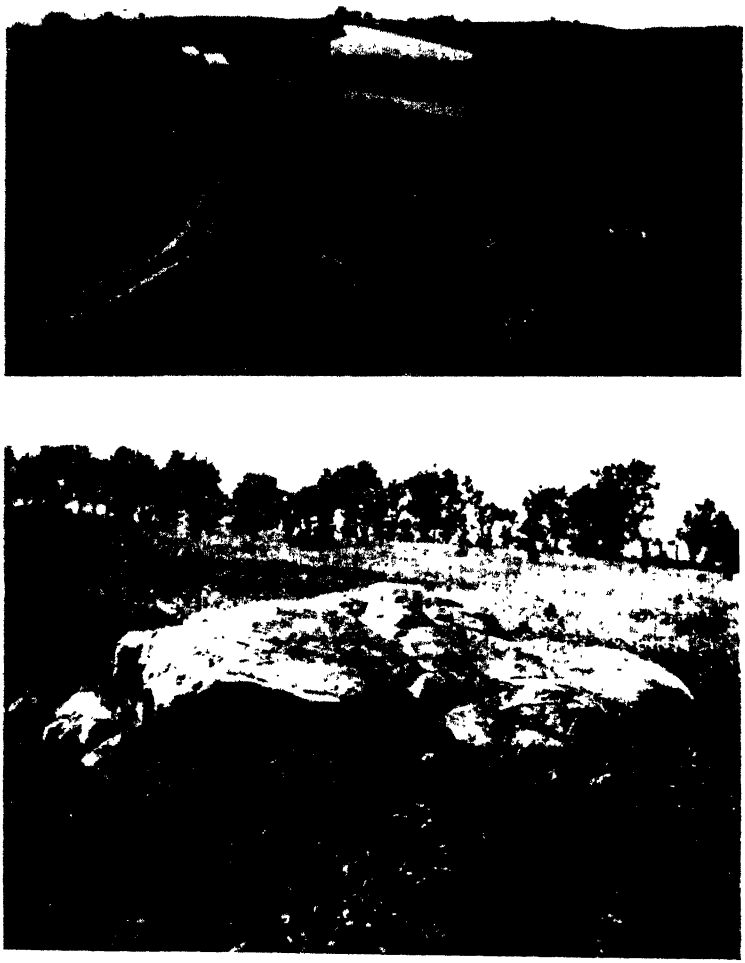


Fig. 28. Drift topography. (A) Loess-mantled drift topography of the Kansas Drift Plain, southeast corner of Doniphan County. Photography by O. Bingham. (B) Large quartzite erratic in the Attenuated Drift Border, near Meriden, Jefferson County. Each leg of folding rule measures 3 feet.

instances are too rough for cultivation and reveal in their precipitous walls ledges of limestone, shale, and some sandstone. The hilliest and roughest portion of the section lies in a strip of country several miles wide and following the bluffs of Missouri River. This part might well be called a minor Kansas Switzerland, (Fig. 28A). Here the upland surface is deeply incised into a complex rugged region of spurs, buttresses, and abrupt convex-sloped hills which lie between sharply cut, steep-walled ravines and valleys having a total relief of 50 to 300 feet and long narrow winding ridges. Drainage is to the Missouri, Kansas, Big Blue, and Nemaha Rivers. The Dissected Till Plains comprise the richest agricultural part of eastern Kansas. Kansas City, Topeka, and Wamego fringe this section. Leavenworth, Atchison, Troy, Hiawatha, Horton, Holton, Seneca, Sabetha, Oskaloosa, and Valley Falls are the more important towns of this area.

Attenuated Drift Border.—The area bordering the Kansas River Valley and that of the Big Blue and Little Blue Rivers, although glaciated and included in Fenneman's Dissected Till Plains section, has an erosional bedrock type of topography and is for the most part similar to the Osage Plains and Flint Hills Upland to the south. It differs from the Osage Plains and Flint Hills Upland in that area has been glaciated and is covered here and there by isolated patches of till, outwash, and more frequently by scattered erratics or boulders, cobbles, and pebbles of ice-transported materials (Fig. 28B). The topography is also less bold than that of the Osage Plains but decidedly rougher and of greater relief than the typical Drift or Till Plains section to the north. The Attenuated Drift Border (Fig. 22) as the unit is here termed, is approximately 25 miles wide paralleling both sides of Kansas River and from 25 miles in Pottawatomie to 35 miles wide in Marshall and Washington Counties. Marysville, Washington, Westmoreland, Wamego, Topeka, Lawrence, and Kansas City are in the Attenuated Drift Border unit.

Arkansas River Lowlands

South of Salina in Saline County and west of the Flint Hills Upland is a low-lying area which for the most part follows the valley of Arkansas River. The surface rocks are chiefly unconsolidated gravels, silts, and clays of Tertiary and Quaternary age. In the southern part of the area in the vicinity of Wellington in Sumner County and in the country contiguous to Slate Creek, a left-sided tributary of Arkansas River, much of the bedrock is of Permian age. Physiographically this low-lying area is here designated the Arkansas River Lowlands and is subdivided into the Finney Lowland, the Great Bend Lowland, the McPherson Lowland, and the Wellington Lowland (Fig. 22). According to Fenneman's classifi-

cation (1931, pl. 1, pp. 27-28) the Finney and Great Bend Lowlands are in the Great Plains province and the McPherson and Wellington Lowlands are in the Central Lowland province. Adams (1903) does not differentiate between the various units of the Arkansas River Lowlands section. On the basis of his mapping (Adams, 1903, p. 113), however, all but the Finney Lowland are included in the Central Lowland province or Prairie Plains province as he termed it. The Finney Lowland is in Adam's High Plains section of the Great Plains province. Topographically the Arkansas River Lowlands are more closely related to the Central Lowland province than they are to the Great Plains.

Great Bend Lowland.—The Great Bend Lowland or Prairie* as designated by Adams (1903, pp. 113, 116-117) is an undulating plain of little relief extending south and east of the great northward bend of Arkansas River from about Dodge City in Ford County to Hutchinson in Reno County and thence southeastward to Wichita in Sedgwick County

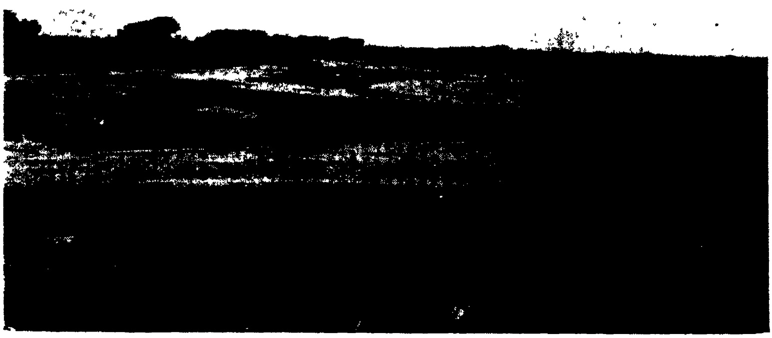


Fig. 29. View of Arkansas River near Kendall, Kearny County, showing typical braided or anastomosing character of the channel typical throughout most of its course. (Courtesy State Geological Survey of Kansas; Smith, 1940)

and Arkansas City in Cowley County (Fig. 22). The Great Bend Lowland is from 25 to 40 miles wide and is traversed in its middle by Arkansas River. Arkansas River flows in a shallow channel developed on the easily eroded Paleozoic shales and the shaly beds of the Dakota sandstone. The river is not confined to a single channel but is characterized by a number of channels with intervening islands producing thus a braided or anastomosing pattern indicative of an aggrading or depositing stream (Fig. 29). In addition to Arkansas River, the Great Bend Lowland is

*The term prairie is primarily a botanical term and denotes "a tract of grassland" and for that reason is abandoned in this paper as unsuited for the naming of physiographic units described in this paper.

traversed to the south of Arkansas River by Rattlesnake Creek and to the north by Cow Creek. Both streams flow, in general, parallel to Arkansas River. Over large areas extreme flatness prevails. Much of the wide, flat, poorly drained valley plain of the river is covered with sandy soil at many places accumulated into low sand dunes. An extensive sand dune belt about 5 miles wide occurs on the northeast side of Arkansas River Valley north and northeast of Hutchinson. The dune belt trends northwest by southeast and lies between Arkansas River and Little Arkansas River. It extends northeast of Burrton in Harvey County to a point east of Saxman in Rice County. Between the dunes small ponds are common during rainy seasons (Williams, 1946, p. 152). In elevation the Great Bend lowland lies from about 1,060 to 2,200 feet above sea level. The surface materials of the Great Bend Lowland are for the most part sands and gravels of Quaternary age.

The origin of the big bend of the Arkansas River and the origin of the Cheyenne Bottoms at and south of Hoisington in Barton County still remain two major unsolved physiographic problems. According to Adams (who probably was the first geologist to explain the great bend of Arkansas River between Ford in Ford County and Wichita in Sedgwick County) and Haworth (1897, pp. 30-32) Arkansas River migrated northward at a place where it began to flow on the easily eroded Dakota sandstone whose dip is to the northeast. Previously the river pursued a course eastward from Ford across the northern part of Kiowa, Pratt, and Kingman Counties, probably leaving Kansas near its present exit from the State. The deflection of the river southward after its down-dip migration to the northeast is explained by the presence of the Flint Hills which served as a barrier preventing an eastward extension of the river. Darton (1915, p. 32) was of the opinion that the shallow structural trough of central Kansas might have been the cause of the notable deflection of Arkansas River to the northward between Dodge City and Great Bend. Hill (1923, p. 165) and others offered explanations for the peculiar course of the river, but none thus far can be established on the basis of field observations. One of the explanations offered is that Arkansas River flowed eastward from Ford in Ford County towards Pratt in Pratt County from which place the river followed essentially the course of the present Ninnescah. The deflection northward was caused by the gradual uplift of a large anticlinal structure whose axis extended in a north-south direction through Pratt. As the structure was slowly elevated the river was forced to migrate northward around the anticlinal structure (Courtier, 1934, p. 69). Courtier (1934, pp. 69-82) accounts for the great bend of Arkansas River as having been caused by headward erosion

and stream piracy during successive tiltings in different directions in this part of the State. As stated previously no convincing explanation of the origin of the Arkansas River bend has thus far been advanced.

In the same category with the big bend of Arkansas River is the Cheyenne Bottoms (Figs. 30 and 31). The Cheyenne Bottoms are in Barton County, primarily in T. 18 S., Rs. 13 and 14 W., about 6 miles

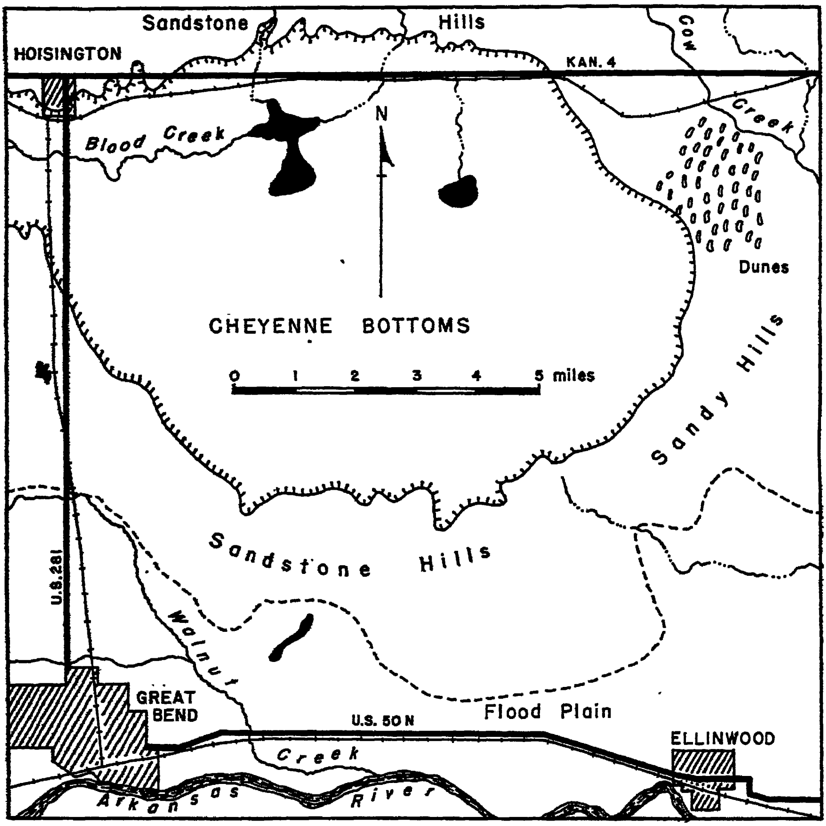


Fig. 30. Map showing Cheyenne Bottoms, Barton County, its size and relation to Great Bend and Hoisington, Kansas.

northeast of Great Bend. Hoisington is in the northwest corner of the bottoms. Cheyenne Bottoms constitute a circular lowland about 6 miles in width and 8 miles in length, and include more than 30,000 acres. The bottoms virtually constitute an enclosed depression being surrounded on all sides by higher land or hills which are quite steep on all sides except on the east. Several small streams of which Blood and Deception Creeks are the most important enter the depression from the north and northwest.

The surrounding hills except on the east side are composed of Dakota sandstone capped on the north and west by the Greenhorn limestone. The east hills consist of loose sand. At the southeast corner of Cheyenne

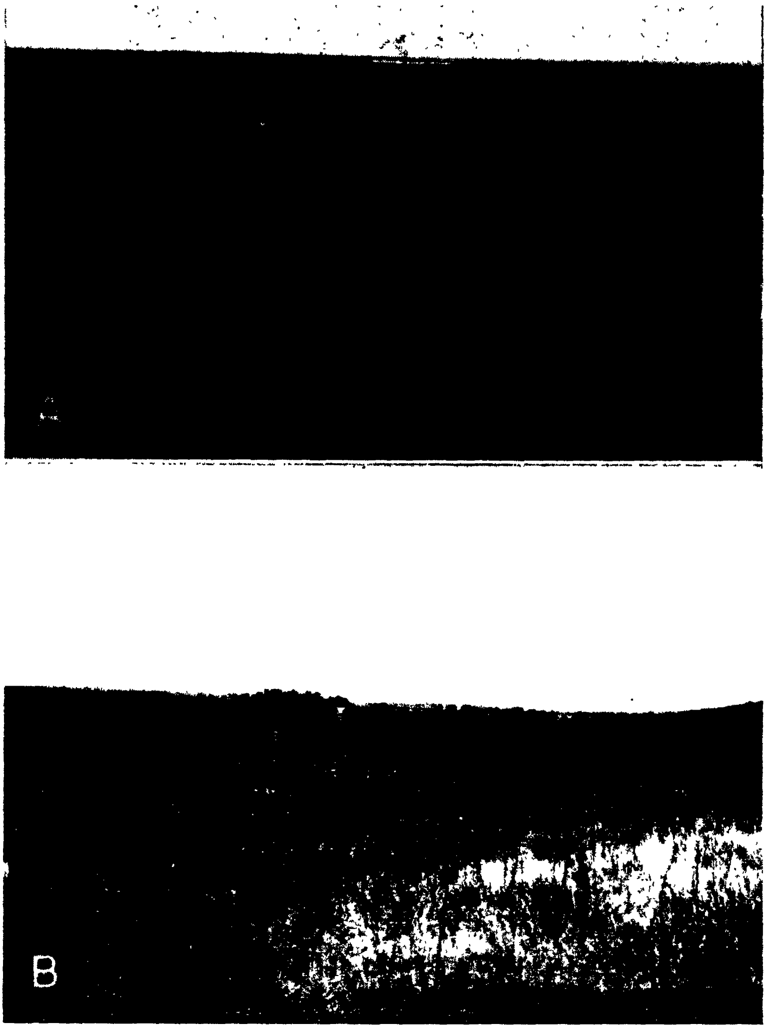


Fig. 31. Views of Cheyenne Bottoms, Barton County. (A) Looking south from the north bluffs and showing the general wide expanse of the 30,000 acre Bottoms. Note several lakes near the horizon. A large lake covering 11,000 acres will occupy part of the Bottoms. (B) North bluffs and part of the flat floor of the Bottoms, view looking towards Hoisington.

Bottoms north of Ellinwood the rim of hills is practically breached. Although the floor of the gap or break is considerably lower in elevation than the top of the enclosing and adjacent wall of hills, the bottom of the gap is above the general level of the basin. Formerly, in every spring of the year, the basin was converted into a large lake by the water draining into it from the surrounding country. The relief of the bottom floor is scarcely more than 5 or 6 feet. The Kansas State Fish and Game Commission is contemplating the construction of an 11,000-acre lake in the Cheyenne Bottoms (Stene, 1945, p. 313) as part of a large wild-life preserve, construction of which has recently started (spring, 1949).

According to Miller (Haworth, 1897, pp. 43-45), the Cheyenne Bottoms constitute the upper part of an ancient valley formed by Blood and Deception Creeks whose courses extended in a southeastward direction. This valley was intercepted by Arkansas River which eroding in the Dakota sandstone migrated or shifted northeastward producing at the confluence of the two valleys a long wedge-shaped ridge. On the basis of Miller's hypothesis, the erosion of the Dakota sandstone released a large quantity of loose sand which was blown into the channel of Blood and Deceptin Creeks forming a drift which gradually increased in length and height until it became a barrier entirely across the valley and thus formed the great basin. The formation of the barrier is explained on the basis that Blood-Deception Creek's flow of water was irregular and insufficient to keep its channel clear of the drifting sand. The Cheyenne Bottoms have also been accounted for by subsidence caused by underground solution of rock salt of gypsum. At present there is no satisfactory and convincing explanation to account for the origin of Cheyenne Bottoms. Wichita, Hutchinson, Great Bend, Kinsley, Arkansas City, Larned, Lyons, St. John, and Sterling are the larger cities in this physiographic unit. Hoisington in Barton County marks the northern limit of the Great Bend Lowland.

Agriculture, the production of oil, the mining and processing of salt, milling, storage, and shipment of grain, meat packing, and fibre-board manufacturing are the most important industries in the lowland.

McPherson Lowland.—Except for origin the McPherson Lowland (Fig. 22) is in most respects similar to the Great Bend Lowland. The lowland is confined primarily to McPherson County extending southward, however, to Little Arkansas River in northeastern Reno and northern Harvey Counties. McPherson, Halstead, Burrton, Mound Ridge, Conway, Galva, Canton, Groveland, Elyria, Inman, Hesston, and Buhler are towns or cities located in the McPherson Lowland. Lehigh and Newton are within a few miles of its eastern margin whereas Lindsborg and Marquette lie just to the north of the area and Hutchinson to the south.

The McPherson Lowland is a flat plain underlain by unconsolidated clays, silts, sand, and gravels from 10 to 250 feet thick, either of Tertiary or Quaternary age. Low sand dunes and undrained depressions constituting ponds and small lakes diversify the topographic expression of the area whose surface lies approximately 1,500 feet above sea level. Little Arkansas River and its tributaries drain the area. Beneath the thick covering of the unconsolidated deposits are the impervious shales of Permian age.

The McPherson Lowland is of great economic importance in that it constitutes one of the most important aquifers or reservoirs of underground water in the State. Wichita, Newton, McPherson, and other cities derive their public water supplies from this lowland area. The clays, silts, sands, and gravels formally known as "Equus beds" (Haworth and Beede, 1897, pp. 295-296) are of Quaternary age. The McPherson formation is the main water-bearing zone in the lowland. As recognized today (Lohman and Frye, 1940, p. 846; Frye and Hibbard, 1941, pp. 270-271; Frye, Leonard, and Hibbard, 1943, pp. 33-34, 46-47) it constitutes a river fill deposit extending in a general direction connecting Halstead with McPherson and Lindsborg. It is believed that the deposit represents an old river bed that connected the Smoky Hill River with the Arkansas River. According to Lohman and Frye (1940, p. 846) the McPherson formation represents the outwash material of the Kansan ice sheet at the time when the continental glacier crossed the present position of Kansas River Valley at Wamego, thus causing much melt water from the ice sheet to fill the Smoky Hill Valley whose drainage was southward by way of Lindsborg to the ancestral Arkansas Valley. A similar glacial origin of the McPherson or Equus formation was advanced by Sharp as early as 1894. In this connection it is interesting to note that according to Frye (Fyre, Leonard, and Hibbard, 1943, pp. 46-47) the Kansas River at this time did not flow across the Flint Hills but came into existence as an east-flowing stream only after the close of the Kansan stage of glaciation. The shift in the drainage of Smoky Hill River from a south-flowing to an east-flowing stream was brought about by a series of piracies which at the present time are not too fully known.

Sand dunes, the most important topographic features of the lowland, occur in an east-west belt, about 5 miles wide, that extends from points south of Medora and Buhler eastward to the Little Arkansas River. The maximum thickness attained by the dune sand is approximately 100 feet (Lohman and Frye, 1940, p. 855). Other but smaller areas of dunes occur between Arkansas River and Kisiwa Creek. These dunes, for the most part low and covered with soil and vegetation, trend in a general

west-northwest direction, parallel to both streams. Their maximum height is about 30 feet.

South and west of McPherson in the Groveland and Inman areas are several natural lakes of which Lake Inman, 3 miles east and 1 mile north of Inman, is the largest. Lake Inman is crudely circular in plan, is shallow, and has a diameter of approximately 0.9 mile. Several elongated shallow depressions, but without water for the most part, are in the same area. The largest of these depressions is 2 miles southeast of Inman and is 2.5 miles long and on the average 0.5 mile wide. It trends northeast by southwest and is in secs. 14, 15, 21, 22, 23, 27, and 28, T. 21 S., R. 4 W. A still larger depression is between McPherson and Conway. This depression or huge sag is approximately 3 by 2 miles in extent and occupies all of sec. 22, most of secs. 23 and 27, a large part of secs. 15. 21, 24, 26, 28, and small corners of secs. 14 and 16, T. 18 S., R. 4 W. The origin of the McPherson Lowland lakes and shallow depressions has not been explained but presumably because of their large size they are best considered as solutional depressions or sags. An alternative hypothesis of origin is that of combined effect of mechanical compaction of the ground particles and chemical solution of the more soluble particles at the sites of the depressions.

Wellington Lowland.—The Wellington Lowland (Fig. 22) or Oklahoma Prairie of Adams (1903, p. 116) is a triangular-shaped area confined primarily to Kingman, Harper, western Sumner, and southeastern Barber Counties. This area, although classified as a minor physiographic unit of the Arkansas River Lowlands, differs from the other three minor units of the Arkansas River Lowlands in that its topography is decidedly rolling in contrast to the more uniform and flat-lying surfaces of the other units. Furthermore, much of the surface is characterized by reddish-colored soil and Permian bedrock is exposed over wide areas of the unit. The eastern border of the Wellington Lowland merges gradually into the western margin of the Great Bend Lowland. To the west, however, the line of demarcation between the Lowland and the Red Hills is sharp and pronounced and is marked by a prominent escarpment, known as the Gypsum Hills. Topographically the lowland lies between 1,140 and 1,350 feet above sea level. Drainage of the Wellington Lowland is by way of Ninnescah River, Slate Creek, Chikaskia River, and Bluff Creek, all of which flow in a general southeasterly direction. Of the cities in the lowland, Wellington, Conway Springs, Caldwell, and Anthony are the more important ones. Agriculture and the production of oil and gas are the two outstanding industries of the Wellington Lowland.

Finney Lowland.—The Finney Lowland includes all of the Arkansas River Valley in Kansas west of Dodge City in Ford County (Fig. 22). It takes its name from the broad dune-covered area in Finney, Kearny, Haskell, and Gray Counties which reaches its maximum extent in Finney County and which Smith (1940, fig. 15, p. 128, 145) named and described as the Finney Sand Plain. The Finney Lowland as here designated includes not only Smith's Finney Sand Plains but also his Arkansas River Valley area (Smith, 1940, fig. 19, pp. 141, 144, 145). The Finney Lowland consists of the valley bottom or inner valley of Arkansas River and the outer valley of the Arkansas, including the terraces and land sloping toward the river but lying below the level of the High Plains section. The inner valley of the river ranges from less than 1 mile to about 4 miles wide. On the north the valley plain is bordered by an almost continuous line of bluffs some of which are 100 feet high and which are extensively notched by short tributary valleys. The greater part of the inner valley of Arkansas River lies south of the river. The topography is essentially flat. Arkansas River which traverses the area flows in a channel from 600 feet wide near Kendall in Hamilton County to less than 300 feet at Cimarron in Gray County 70 miles farther east. The river is an anastomosing or braided stream which during much of the year is characterized by little or no flow as the water is diverted for purposes of irrigation. According to Smith (1940, p. 18) Arkansas River falls on the average 6 feet per mile in the Finney Lowland section. The river is unusual in that its channel is higher by several hundred feet than that of Smoky Hill River to the north and Cimarron River to the south, although Arkansas River enters the State at a lower elevation than do the other two streams. The "perched" position of Arkansas River Valley is not fully accounted for. Crustal warping and overload of the river (Smith, 1940, p. 144) and greater relative depth to the impervious bedrock floor along the Arkansas than to the other streams (Fenneman, 1931, pp. 23-25) are possible factors that may have contributed to this anomalous condition.

At least two terraces occur along the Arkansas River Valley in the Finney Lowland. The lower terrace, also called "second bottoms" (Darton, 1920, p. 3) is from 5 to 8 feet above the flood plain whereas the higher terrace is from 15 to 25 feet above it. Fossil bones of bison, horse, and elephant have been found in the terrace sands and gravels suggesting a late Pleistocene age for these deposits (Smith, 1940, p. 126).

The outer valley of Arkansas River is from 5 to 20 miles wide. Near the Colorado line the depth of the outer valley is about 300 feet whereas near the eastern border of the Finney Lowland, its depth is approximately 100 feet. Extending from southeastern Kearny County to central Gray

County is an area of sand hills (Fig. 36) to which Smith (1940, pp. 140, 145, fig. 19, p. 141) has given the name Finney Sand Plain. The sand plain belt reaches its maximum width in Finney County. It is an area of sand dunes, sand ridges, sand waves, and blow outs whose maximum relief is about 70 feet and whose average relief is about 35 feet. The dunes according to Smith (1940, p. 154) are from 300 to 1,400 feet long although in some places they are as much as a mile or more in length. In the dune area, surface drainage is lacking for entering streams are soon lost or disappear in the sandy materials. The sand dunes are not restricted to the Finney Sand Plain area but extend more or les continuously westward to the Kansas-Colorado State line along Arkansas River. According to Smith (1940 a, p. 308), the largest expanse of free dune sand in the State is found south of the river west of Syracuse in a belt about 1.5 miles wide and about 4 miles long. The dunes have the appearance of great waves of sand and are nearly a mile long and 30 feet high. Smith states that of all the sandhill areas in the State, the one south and southwest of Syracuse in Hamilton County exhibits the greatest wealth of scenic attractions in Kansas. In describing the area, he (Smith, 1940 a) states: "In this locality there are all transitions from bare, moving dunes (Fig. 32B) to old, well-stabilized dunes (Fig. 32A). The free-moving dunes duplicate, on a smaller scale, the forms found in the great deserts of the world. . . . Standing in the center of the dune area, one sees seemingly endless wavelike forms stretching in all directions. Some of the sand waves are nearly straight, some are broadly curved, others sharply and irregularly curved, and all are asymmetric, having one steep side and one gentle slope. In detail the forms show endless variety, with smooth, graceful curves in one place, and abrupt, tumultuous forms in another. And with every strong wind their contours are gradually changed. Bordering the sand waves', and to some degree interspersed with them, are the grass-covered dunes." This area is worthy as being set aside as a State sand dune monument. Cimarron, Garden City, Lakin, and Syracuse are the largest cities in the Finney Lowland. Dodge City is at the junction of the Finney and Great Bend Lowlands.

The Great Plains Province

Of the three physiographic provinces represented in the State, the Great Plains Province (Figs. 21 and 22) is the largest. It includes all of western Kansas and extends eastward on the north as far as Washington County, in the center, to McPherson County, and Sedgwick and Sumner Counties on the south. The Great Plains are made up of the High Plains and Dissected High Plains sections and are divided by the Arkansas River

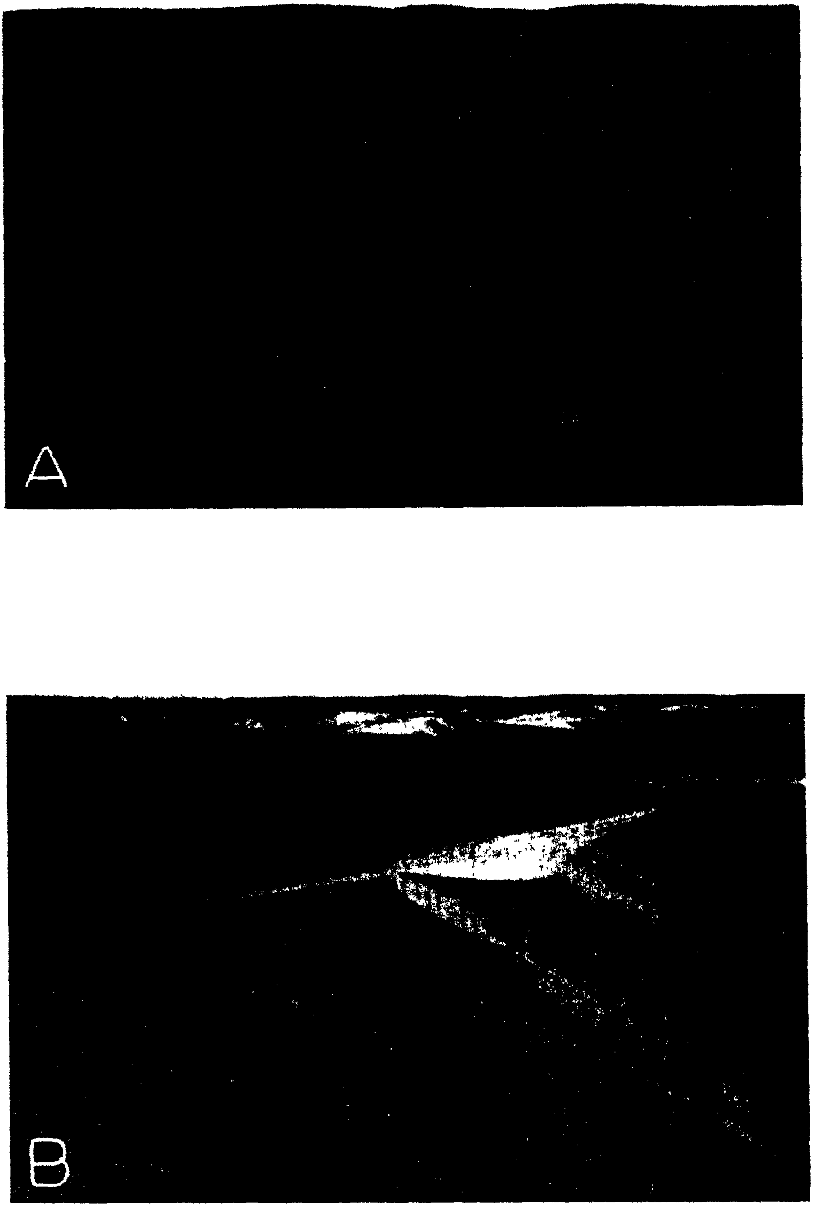


Fig. 32. Sand dune topography, Finney Lowland. (A) Old, well-stabilized dunes southeast of Deerfield, Kearny County. (B) Active sand dunes about 4 miles southwest of Syracuse, Hamilton County, Kansas. (Courtesy State Geological Survey of Kansas; Smith, 1940)

Lowland extension of the Central Lowland Province into a northern and into a southern area. (Fig. 22).

Dissected High Plains

The Dissected High Plains are made up of the Red Hills, the Smoky Hills, and the Blue Hills of which the latter two are north of Arkansas River and the former south. Whereas the Red Hills are underlain by rocks of Permian age, the surface strata of the Smoky and Blue Hills are Cretaceous in age. As originally described (Adams, 1902, pp. 96, 102-103) the Smoky and Blue Hills were combined into the Smoky Hills Upland and the Red Hills were called the Red Hills Upland. All three of the hill units are included in Fenneman's Plains Border section, the term here abandoned and replaced by the more appropriate term Dissected High Plains.

Red Hills or Cimarron Breaks.—Perhaps the most scenic part of the State lies in the physiographic unit that has been named the Red Hills (Fig. 22) (Adams, 1903, pp. 113, 120) or the Cimarron Breaks (Moore, 1930). The Red Hills or Cimarron Breaks constitute the highly dissected border of the Great Plains south of the tongue-like eastward projection of the High Plains and included in Fenneman's Plains Border. This physiogaphic unit extends on the west from eastern Meade County eastward to Anthony in Harper County and on the north from a line 20 miles south of Greensburg in Kiowa County, Pratt in Pratt County, and Kingman in Kingman County southward to the Kansas-Oklahoma State line. Ashland, Coldwater, Medicine Lodge, and Anthony are included in its confines. The underlying rocks of the unit are the red shales, siltstones, and sandstones, including gypsum and anhydrite, of Permian age. The name Red Hills is derived from the red color of the soil and rocks exposed in that part of the State and the name Cimarron Breaks refers to the abrupt and sharp break in the topography marking the edge of the High Plains along the valley of Cimarron River. The "breaks" proper constitute a belt 10 to 20 miles wide, having local relief as much as 300 feet (Smith, 1940, p. 23) and total relief of 500 feet. Topographic forms of common occurrence are small, table-like plateaus and flat-topped hills (Fig. 33A). Barber County is especially a land of many steep-sided buttes, pyramids, pinnacles, buttresses, and stream valleys lined by steep bluffs (Fig. 33 B and C). The scenery is greatly enhanced by the bright-red colors of the Permian shales, silt-stones, and sandstones capped by relatively resistant white gypsum beds (Hay, 1890, pp. 20-24). The Red Hills are drained primarily by Cimarron and Medicine Lodge Rivers and their tributaries.

Topographic features due to the solutional effect of ground water is

responsible for the natural bridge (Fig. 34A) and cave near Sun City in western Barber County and the Big and Small basins near Ashland in western Clark County (Fig. 34B). The natural bridge is about 35 feet wide and 55 feet across. The top of the arch is approximately 12 feet above the level of the intermittent stream which it spans. A tunnel-like

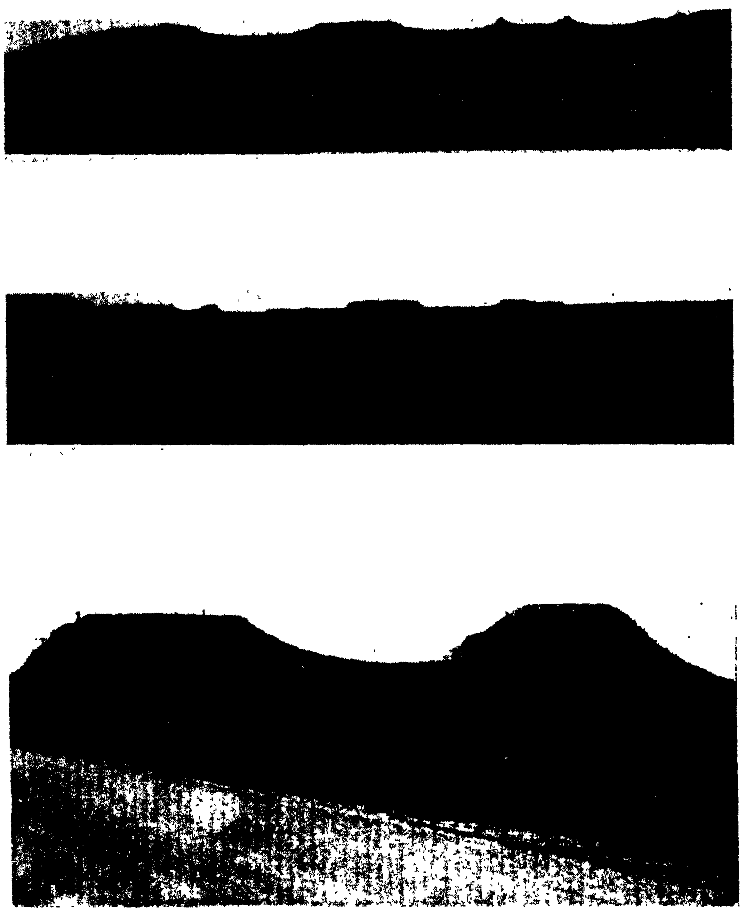


Fig. 33. Red Hills section views, Barber County. Butte and mesa topography. (A) Eight miles southwest of Medicine Lodge. (B) Five miles southwest of Sun City. (C) Characteristic mound or butte scenery along U. S. Highway 160 between Medicine Lodge and Coldwater.

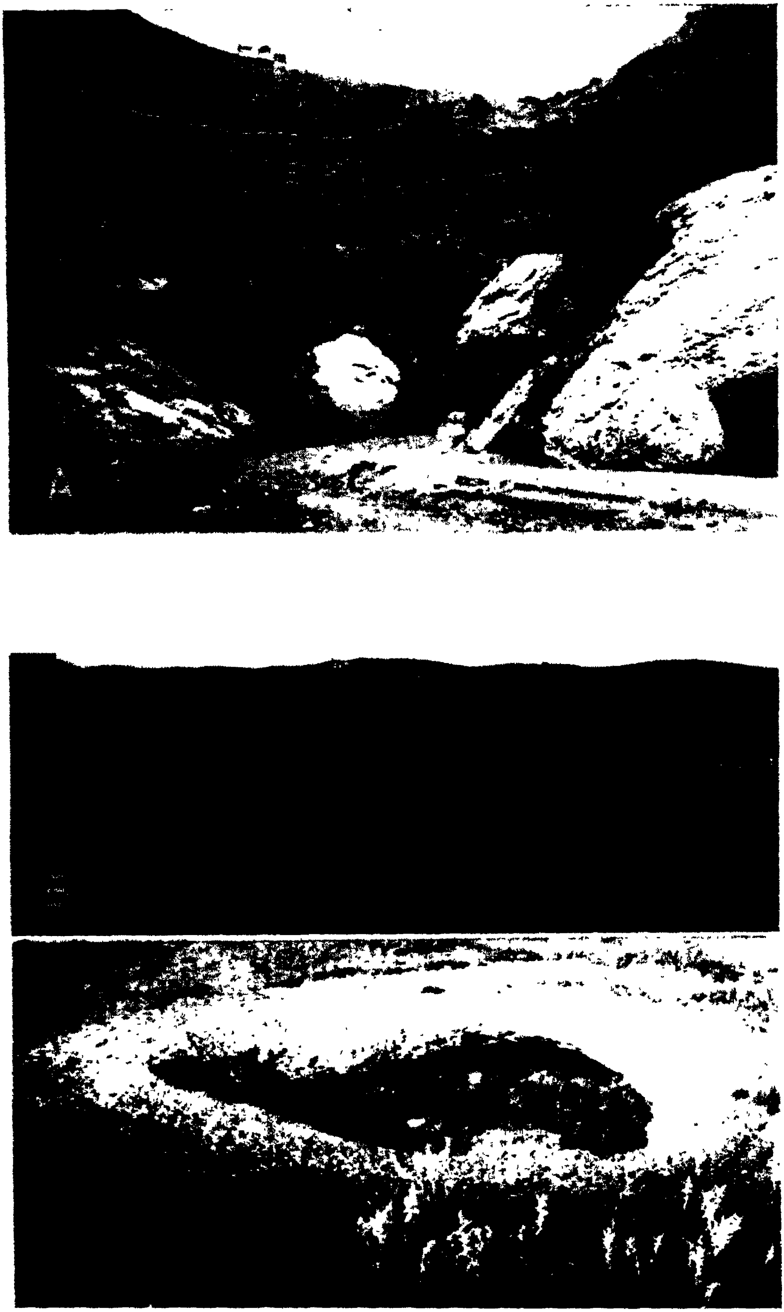


Fig. 34. Red Hills section views. (A) Natural bridge 6 miles south of Sun City, Barber County. (B) Big Basin, view looking east from U. S. Highway 283, 12 miles south of Minneola, Clark County. (C) Beginning of a sink hole or a natural bridge near the site of the natural bridge shown in A.

cave about 260 feet long with one of its openings immediately beneath the downstream or north edge of the bridge is associated with the natural bridge on the west bank of the stream. Both bridge and cave have been carved from the gypsum. The bridge has been explained (Landes, 1935) as having been caused by the circulation of underground water at a time when the surface was higher than now forming a cave in about the position of the present stream channel, similar to the tunnel-like cave immediately to the west of it. Surface water seeping its way into the cave found its way downstream or to the north where it reappeared at the place where the valley floor had been cut below the base of the gypsum bed in which the cave was excavated. Later when solution had created a sufficiently large opening (Fig. 34C) or openings with the surface, the stream plunged into the tunnel-like cave and pursued its course underground, emerging again as a surface stream some distance to the north. In time as the ends of the tunnel gave way and gradually retreated, the tunnel and underground course of the stream dwindled in length until today the only part remaining is the present natural bridge. Detailed directions for finding and reaching the natural bridge and west-bank cave are indicated on Figure 35B. General location is shown on the index map (Fig. 36).

The Big Basin and Little Basin including St. Jacob's well are sink holes. Both features are in western Clark County. The Big Basin is traversed north and south by highway U. S. 283 and is 2.2 miles south of the junction of highway U. S. 160 with 283 (Fig. 35A). The Big Basin is a subcircular undrained depression about 100 feet deep and a mile in diameter. Unless told that the Big Basin is a large sink hole, one traveling the High Plains between Dodge City, Minneola, Englewood, and Ashland would mistakenly consider the undrained depression simply as a mile-wide prominent valley. The absence of any stream together with a casual look in all directions, however, should be sufficient to show that the low-lying area is entirely circumscribed by red and white colored rocky bluffs and is not a valley but a depression entirely surrounded by higher country. The floor of the basin is essentially flat which, however, does contain a number of low places which are the sites of shallow ponds during and shortly after the wet season. A small, steep-sided depression or hole occurs near the east side of the basin. The rocks in the surrounding bluffs are of Permian, Cretaceous, and Tertiary age and at many places are notched by small gullies and ravines. Geologically the Big Basin is not old. Whether it was formed several hundred or thousands of years ago is not known. The fact, however, that the streams entering the basin from the north have cut down their original level to the level of the basin

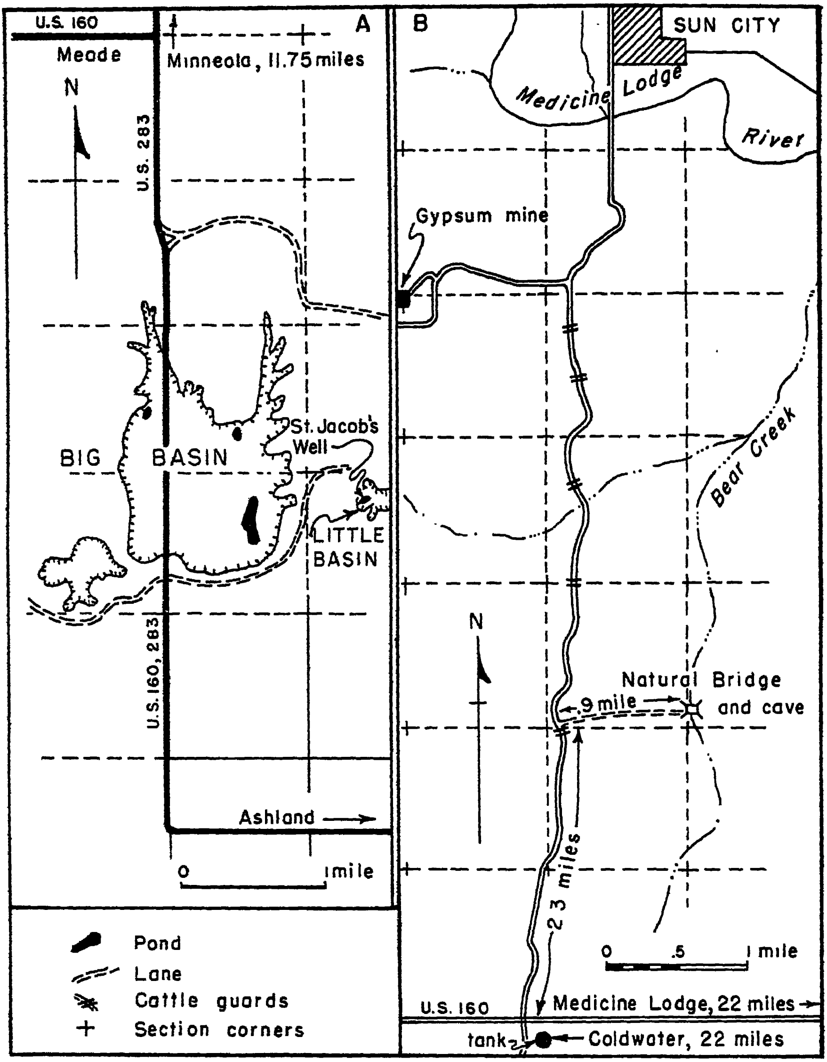


Fig. 35. Maps showing location of (A) Big and Little Basins in Clark County. (B) Natural bridge in Barber County, Kansas.

floor to which they are now adjusted suggests that the origin dates back to thousands of years rather than to hundreds.

The Big Basin owes its origin to solution and collapse and has no association whatsoever with volcanic activity as had been advanced within recent years by some unscrupulous gold and silver mining and promoting outfits. Whether the basin was formed by the collapse of the roof of a single cave about 1 mile in diameter and more or less similar in size to

the Great Room in Carlsbad Cave, New Mexico, or whether it was formed by the gradual merging or coalescing of a number of sinks formed by the collapse of the roofs of a cluster of smaller caves is not established.

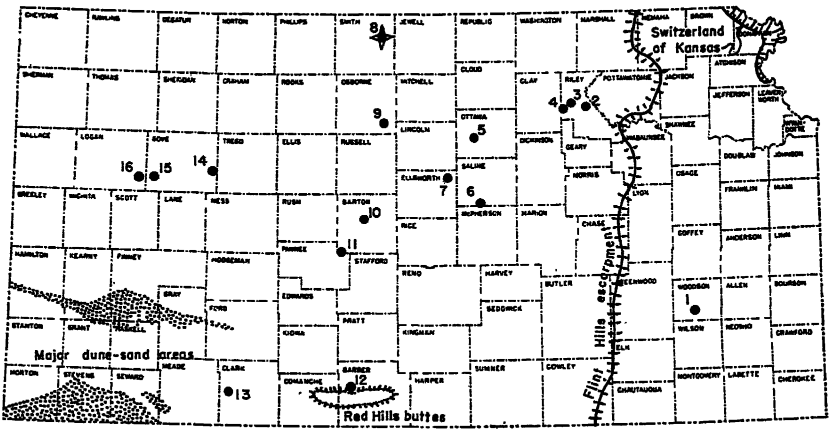


Fig. 36. Index map of Kansas showing general locations of the better known natural scenic spots in the State. (A) Rose igneous intrusive, (B) Stockdale igneous intrusive, (C) Leonardville igneous intrusive, (D) Bala igneous intrusive, (E) Rock City concretions, (F) Coronado Heights, (G) Palmers Cave, (H) Geographic Center of the United States, (I) Geodetic Datum of 1927, (J) Cheyenne Bottoms, (K) Pawnee Rock, (L) Natural bridge, (M) Big and Little Basins, (N) Castle Rock, (O) Sphynx and other Monument rocks, (P) Bad Lands and chalk canyons.

The presence of smaller sinks at the southwest and at the east sides of the basin suggests the possibility of gradual coalescence, although its outline is more regular than might be expected on that basis (Smith, 1940, p. 170).

Little Basin is a deeply gullied small sink about 35 feet deep and about a half mile east of the east rim of Big Basin. This sink hole is especially attractive for the pool of standing water which it contains and which is known as St. Jacob's well. To reach St. Jacob's well see Figures 35A and 36.

A small topographic unit within the Red Hills is the Englewood-Ashland Basin in southeastern Meade and western Clark Counties. The basin is a broad lowland, 12 miles wide at places and about 500 feet below the High Plains level. It is drained by Cimarron River and its tributaries. The Englewood-Ashland Basin has been explained to stream erosion (Haworth, 1897a, pp. 21-22), to solution and collapse (Johnson, 1901, pp. 711-712; 722-724), and to a combination of downwarping, stream erosion, and supplementary solution and collapse (Smith, 1940, p. 139).

Smoky Hills.—The Smoky Hills (Fig. 22) constitute a strip of

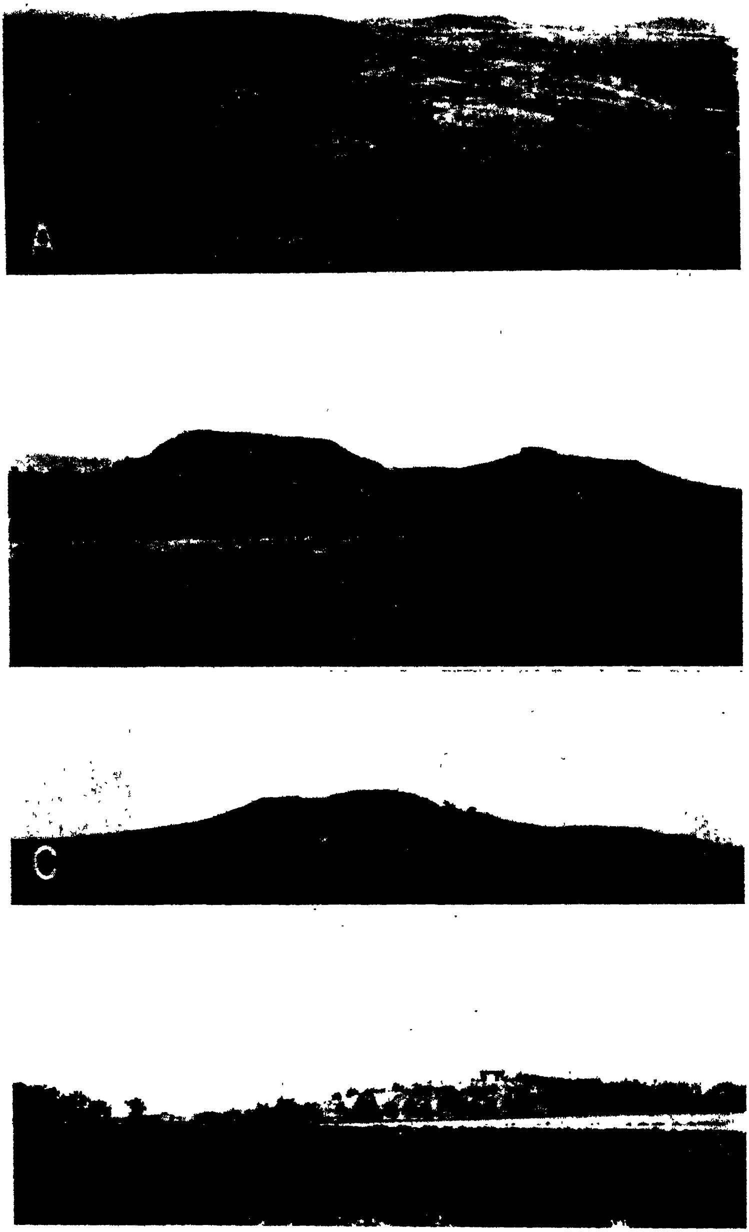


Fig. 37. Smoky Hills section views. (A) Rolling landscape developed in Dakota sandstone, view looking north from tower on Coronado Heights, Saline County. (B) Dakota sandstone mounds at Terra Cotta, Ellsworth County. (C) Coronado Heights, norwthest of Lindsborg in Saline County. (D) Pawnee Rock, a Dakota sandstone hill, southeast corner of Barton County.

country 20 to 40 miles wide forming the eastern part of the Dissected High Plains section and lying north of the Arkansas River Valley. Its western limit is marked by the east-facing escarpment of the Greenhorn limestone which marks the beginning of the Blue Hills. The Smoky Hills are a maturely dissected broad hilly belt (Fig. 37A) carved essentially in the Dakota sandstone and having a relief at places from 200 to 300 feet. In general, however, the relief is much less and the topographic features are largely indistinct terraces and dissected escarpments. Numerous outlying hills and mounds (Fig. 37B) characterize this unit such as Smoky Hill Buttes and Soldier Cap Mound in Saline County. In addition there are prominent landmarks such as Coronado Heights (Figs. 36, 37C, 38) in Saline County, 3 miles northwest of Lindsborg; Pawnee Rock (Figs. 36, 37D, 39) at Pawnee Rock in Barton County; Palmer's Cave or Cave Hollow (Figs. 36, 40, 41) with its hieroglyphic decorated sides, ceilings, and passageways, about 5 miles north of Carneiro in Ellsworth County; and the unique area of huge concrections known as Rock City (Figs. 36, 42, 43) 2½ miles southwest of Minneapolis in Ottawa County. Rock City is not only strikingly unique geologically, but also, as far as known, is not duplicated anywhere else in this country. At least 200 individual sandstone concretions of various shapes and ranging in size from 8 to 27 feet in diameter dot the landscape. The concretions represent local spots within the Dakota sandstone where the sand grains have been cemented together more firmly than in the rest of the rock by lime carried in solution and deposited by circulating ground water. During the process of weathering and erosion the softer sandstone has been removed leaving thus behind the more firmly cemented concretions.

The Smoky Hills are traversed from west to east by the Republican, Solomon, Saline, and Smoky Hill Rivers. The Smoky Hill River between Lindsborg in McPherson County and Salina in Saline County flows northward. The valley of all the streams mentioned are in general wider in the Smoky Hills than they are farther downstream in the Flint Hills Upland section where the rocks are much more resistant to erosion than where cut in the weaker Dakota sandstone. The name Kearney Hills (Haworth, 1897, p. 48) has been applied to that part of the Smoky Hills lying west of Salina. Ellsworth and Minneapolis lie within this topographic unit. Belleville, Concordia, Beloit, and Lincoln are cities located along its western margin, whereas Washington, Clay Center, Salina, Lyons, Great Bend, Larned, and Jetmore mark its eastern border. Excellent ceramic clays are exploited in this physiographic unit.

Blue Hills.—The Blue Hills (Fig. 22) lie immediately west of the Smoky Hills. The Blue Hills are so called in allusion to the bluish haze

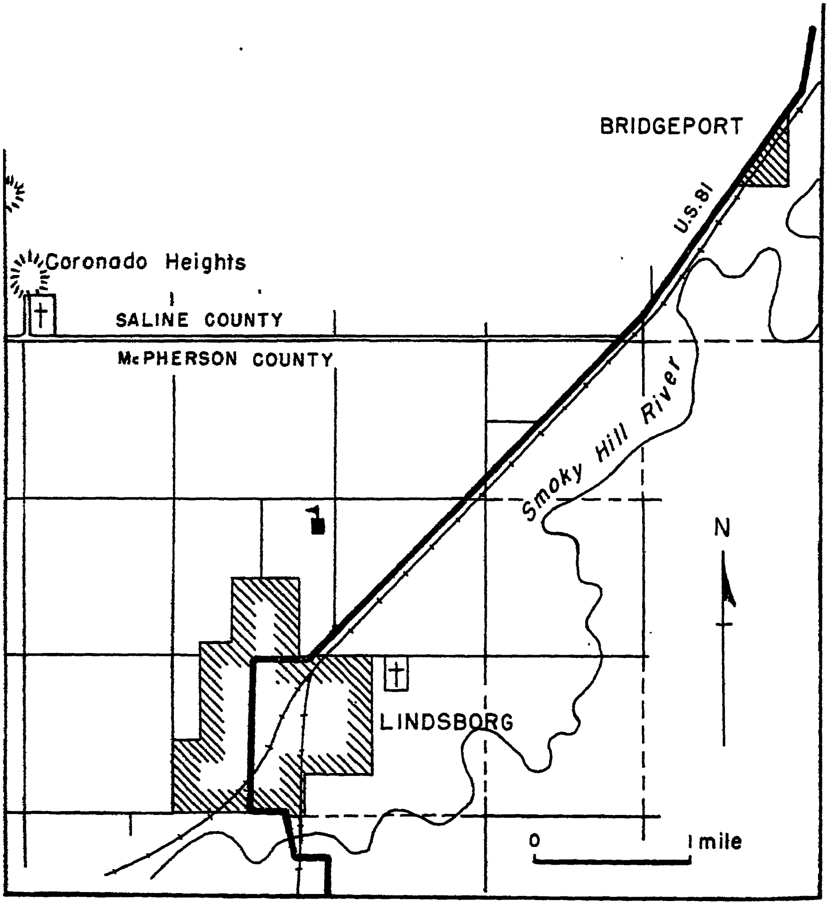


Fig. 38. Map showing location of Coronado Heights, Saline County, Kansas.

the atmosphere frequently presents when looking at the hills from a distance (Haworth, 1897, p. 47). Like the Smoky Hills, the surface of this unit is underlain by strata of Cretaceous age. The rocks of the Blue Hills, however, consist chiefly of inter-stratified limestones and shales—rocks that produce a much more regular type of topography than does the less uniformly bedded Dakota sandstone. The Blue Hills are characterized by two dissected cuestas of which the easternmost one is controlled by the Greenhorn limestone and the westernmost one by the outcropping of the Niobrara chalk. The Blue Hills in southwestern Mitchell County and similar hills in Osborne County rise conspicuously above the surrounding country. Relief from 200 to 300 feet per mile is not uncom-

mon. Wherever the surface is eroded into the nonresistant shales, the topography is rolling, whereas where the exposed rock is the more resistant limestone, a flat plateau-like surface is the rule, whose escarpments are steep and rocky. In the area where the Fort Hays limestone, the basal member of the Niobrara formation, occurs, the surface is characterized by flat-topped buttes and small mesas. The Fort Hays

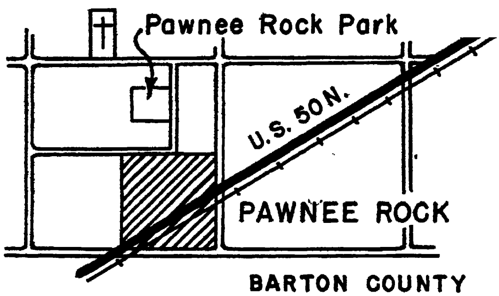


Fig. 39. Map showing location of Pawnee Rock, Barton County, Kansas.

limestone is topographically one of the most prominent of the rock units in central Kansas. At many places, especially in Russell County, it forms the cap rock of the hills that stand 100 feet or more above the surrounding country. Isolated buttes, some small and nearly conical, others long and flat-topped, are common near the escarpment edge, whereas some stand at distances of nearly a mile from it (Rubey and Bass, 1925, p. 30). In general the elevation of the Blue Hills section is between 1,400 and 2,000 feet above sea level.

The Republican, Solomon, Saline, and Smoky Hill Rivers and Walnut Creek traverse this upland from west to east. The rivers occupy valleys which usually are flat-bottomed and which range in width from less than 1 to several miles. The relief along Saline River in Russell County is 250 to 300 feet and that along Smoky Hill River is 150 feet or less. The north-facing river bluffs are chacteristically steep and short whereas the south-facing valley walls are much gentler and longer, a feature which is characteristic of many of the river valleys of western Kansas.

Mankato, Belleville, Stockton, Osborne, Beloit, Hays, Russell, and LaCrosse are the most important cities in the Blue Hills Upland section. Oil and gas are important mineral resources of the unit and farming and grazing constitute the chief occupation of the residents of the area.

High Plains.—The High Plains (Fig. 22) are a treeless and, in general, on a regional basis, a featureless plain (Fig. 44) that covers

approximately 30,000 square miles or about 36 per cent of the land area in the western one-third of the State. The High Plains constitute the most level part in Kansas and to many people represent the typical or characteristic landscape descriptive of the State as a whole, a view, which, however, is far from being accurate and true. The High Plains surface

Fig. 40. Palmer's Cave or Cave Hollow, 6 miles northeast of Carneiro, Ellsworth County, Kansas.

rises gradually westward at an average rate of 10 to 15 feet per mile. Locally, the surface slope may be as low as 5 to 7 feet as in parts of Finney and Gray Counties or as high as 30 feet per mile as in parts of Hamilton, Kearny, Grant, Haskell, and Stevens Counties. In elevation the High Plains surface lies between 2,000 and 4,000 feet above sea level. The highest elevation in the State is 4,135 feet above sea level and is on the slightly rolling divide between the basins of Goose Creek and Willow Creek in sec. 12, T. 12 S., R. 43 W. This spot is close to the Kansas-

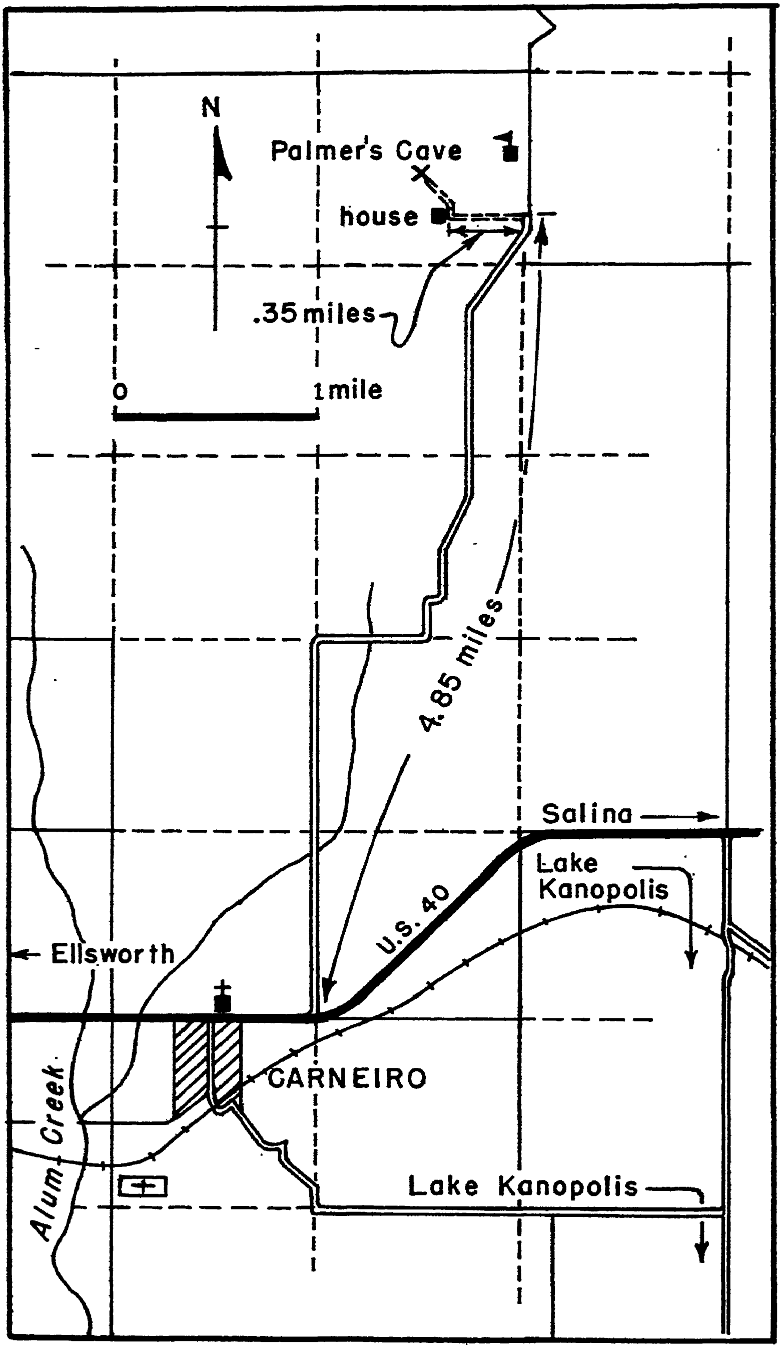


Fig. 41. Map showing location of Palmer's Cave, Ellsworth County, Kansas.

Colorado boundary and about 11 miles north of a point in Wallace County where U. S. 40 crosses the State line.

Although the High Plains constitute a partly dissected plateau characterized mainly by broad reaches of flat uplands which in places are undrained, the surface, however, is not without relief and surface expres-

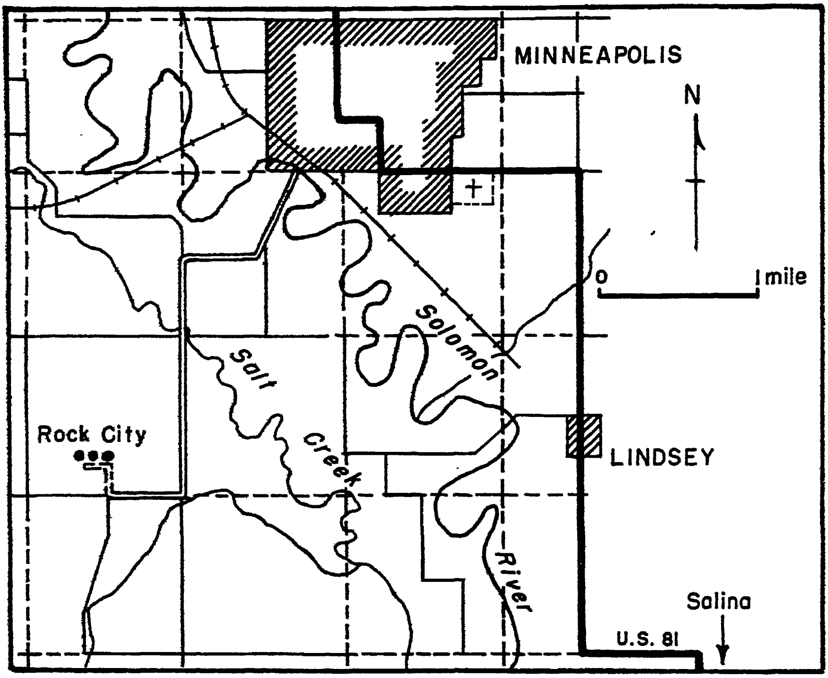


Fig. 42. Map showing location of Rock City near Minneapolis, Ottawa County, Kansas.

sion. Locally, the relief may be as much as 300 feet. Major river valleys such as the Smoky Hill, Arkansas, and Cimarron traverse this topographic unit and many other streams have their origin in it. The major river valleys are broad and have gentle side slopes that extend downward to relatively narrow flats (Fig. 45). Minor valleys in many places are steep-sided narrow canyons. Despite the general low relief of the High Plains there are areas that are "dimpled," hummocky, and covered with sand dunes (Frye, 1946, p. 74).

Scattered far and wide over the High Plains and present virtually everywhere in the upland areas are numerous depressions or basins (Fig. 46). These depressions which are numbered by the thousands and which constitute characteristic topographic features of the High Plains range in diameter from a few feet to several miles. By far most of them are very

shallow, usually less than 10 feet in depth. Some of the larger depressions, however, attain a depth of 40 to 50 feet. In ground plan many of the depressions are circular to subcircular, whereas others are linear in shape. Still others have no particular pattern and may be designated as

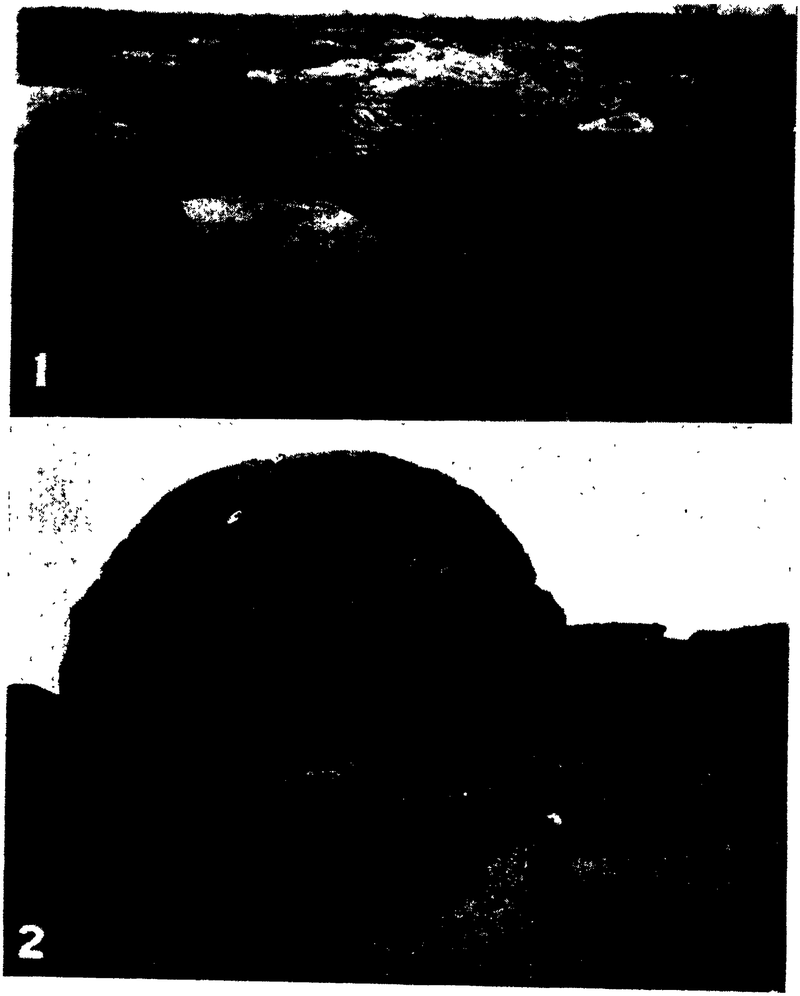


Fig. 43. Rock City concretions. (1) General view. (2) Large round concretion of Dakota sandstone fully exposed. Compare size with that of child forty-two inches tall.

being irregular in ground plan. A tendency toward directional orientation is manifest among the linear type of depressions. In the Scott City area (Scott County) the trend of the linear depressions is in a general north-south direction, whereas in the Colby (Thomas County) area (Frye, 1945, pp. 29-31) they are aligned in a northwest-southeast direction. Although small depressions predominate and probably are to be numbered by the thousands, there are some large depressions. One of the largest of these depressions is the Modoc Basin or Scott Basin (Waite, 1947, p. 18) (Fig. 47) just south of Scott City in Scott County. This basin covers

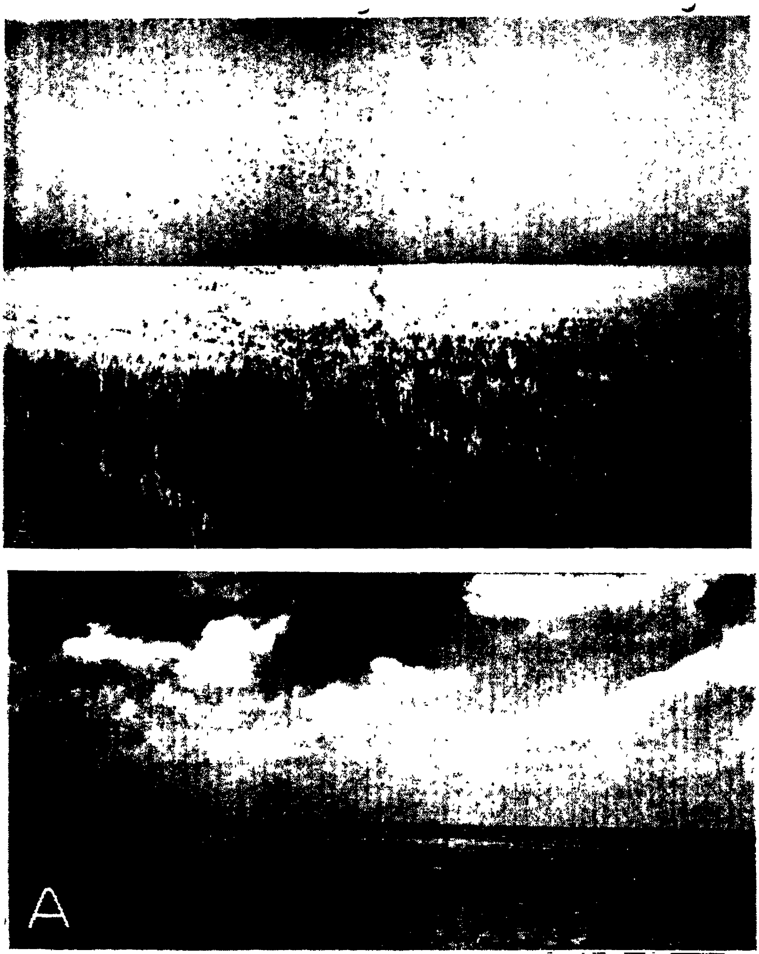


Fig. 44. High Plains topography. (Upper A) Flat, featureless topography typical of the High Plains of Stanton County. (Lower A) View of the High Plains in northern Kearny County, Kansas. (Courtesy State Geological Survey of Kansas; Latta, 1941; McLaughlin, 1943)

approximately 19 square miles and at its widest part is close to 6 miles wide. The Modoc or Scott Basin is not apparent to the eye because of its shallow depth of only about 15 feet and because the basin is dry during most of the year. However, following heavy rains, considerable water collects in the basin forming a lake that sometimes covers several square miles. The lake does not long exist as the water sinks rapidly into the

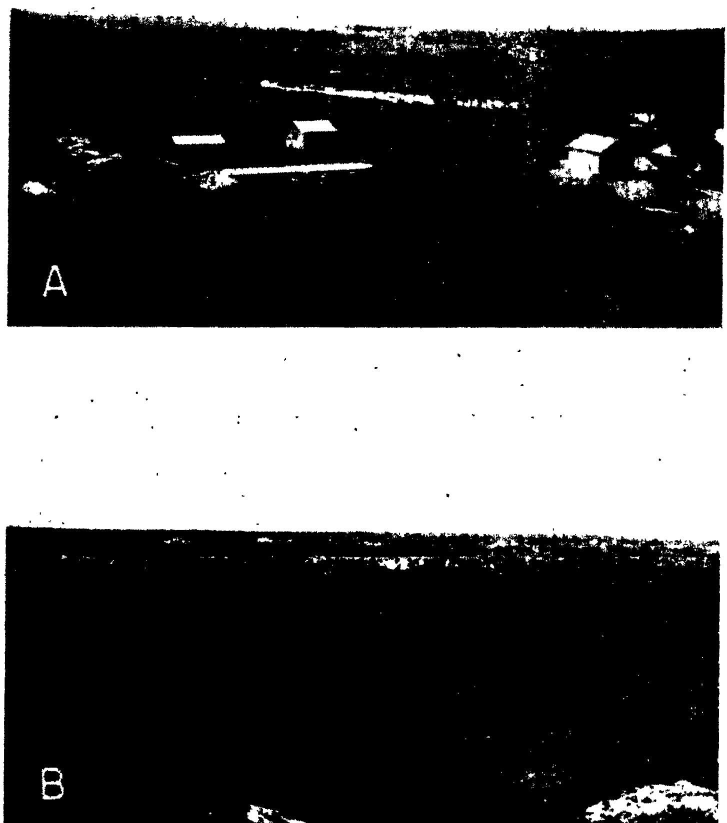


Fig. 45. Dissection of High Plains, Smith County, Kansas. (A) Broad and shallow valley of Beaver Creek at Camp Cristy, 10 miles north of Scott City. (B) Beaver Creek valley to the north of A showing steep rock-walled bluffs and more canyon-like character of the valley.

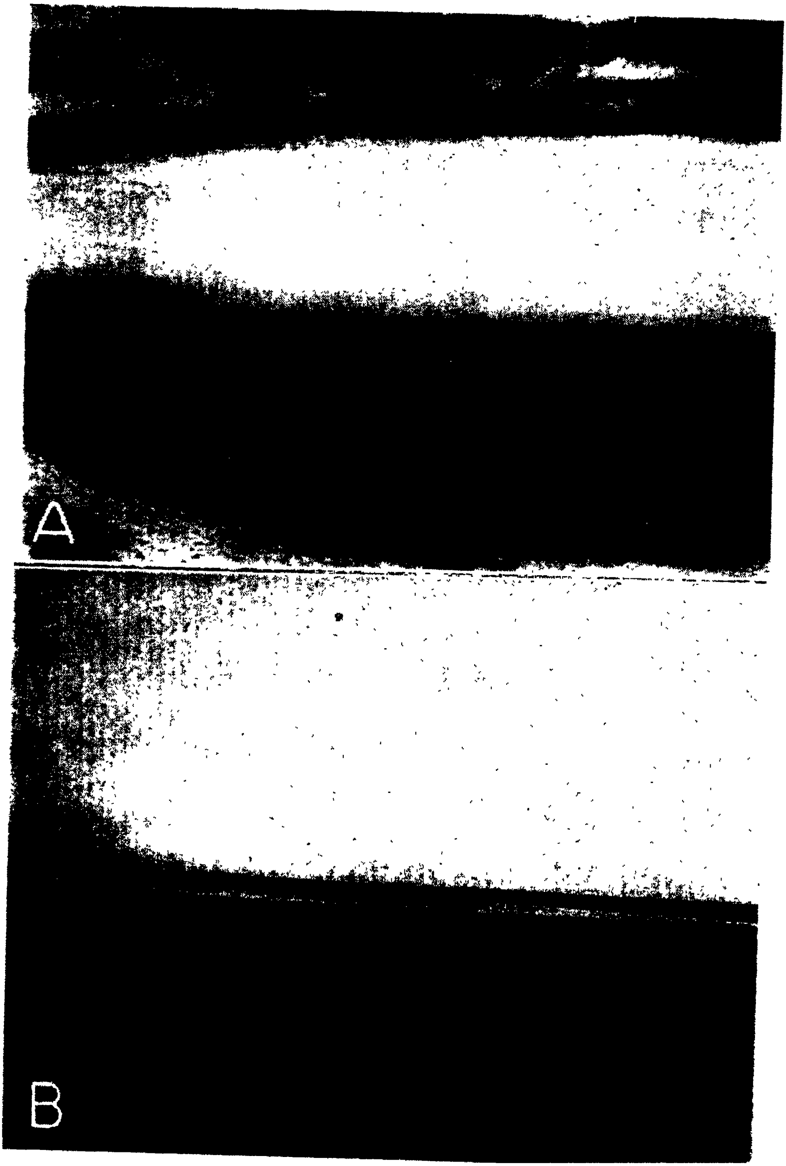


Fig. 46. Depressions on the High Plains surface. (A) Water-filled depression on the High Plains surface in Kearny County, sec. 26, T. 22 S., R. 38 W. (B) Typical view of small depression filled with water after rains, sec. 26, T. 18 S., R. 32 W., Scott County, Kansas. Depressions shown in A and B are characteristic features of the High Plains and are present by the hundreds. (Courtesy State Geological Survey of Kansas; McLaughlin, 1943; Waite, 1947)

ground, disappearing completely in a relatively short time. Whitewoman Creek and short ephemeral streams flow into the basin from the west but soon disappear entirely on the western side of the basin. Several large depressions but smaller than Scott Basin occur in the Scott City area (Fig. 47). Immediately west of Scott City is a broad shallow depression more than 2 miles long and about 1 mile wide. South of the Scott or Modoc Basin is a linear depression 2½ miles long and three-fourth mile wide. This is the Shallow Water Basin. Dry Lake is another depression 2.4 miles long and 0.4 mile wide. It is 6½ miles east and 4 miles south of Shallow Water. Figure 47 is a map showing the number, relative sizes, and distribution of the depressions in the Scott City area which might be considered as being typical of the High Plains in so far as the depressions are concerned. The deeper depressions are usually of the sink-hole type (Fig. 48). Most commonly they are circular in ground plan, have steep walls, diameters seldom exceeding several hundred feet, contain ponds, and are from 50 to more than 150 feet deep. A number of such depressions have originated within historic times and as recently as 1926 when the Sharon Springs cave-in in Wallace County occurred (Moore, 1926, 1926a; Elias, 1931, pp. 229-234) and 1929 when a sink formed 7 miles northwest of Irene or 11 miles south of Coolidge in Hamilton County (Landes, 1931) (Fig. 49A).

It is evident that not all of the depressions of the High Plains are of the same origin. The very small saucer-shaped and shallow depressions have been described as "buffalo wallows" and have been attributed (Darton, 1915, pp. 36-37 footnote 2) to the combined action of buffalo and the wind. According to this hypothesis the sod around a water hole or salt or alkali lick is pulverized by the tramping of the hoofs of buffalo, originally started around a salt or alkali lick or around a water hole. Buffalo milling around such places in great numbers, tramping the soil thin and pulverizing it, was the first step in the formation of the so-called "buffalo wallows". Wind later removed the finely pulverized soil, much of which when wet was carried away in the shaggy pelts of the buffalo who delighted to roll in the dirt and thus formed the shallow depressions which are present by the hundreds on the High Plains surface. Undoubtedly some of the depressions have been formed in this manner. Other depressions, however, are too large and too deep to have been formed by the combined action of buffalo and wind. Certainly some of the circular and deeper depressions are true sink holes—that is, depressions caused by the collapse of the roofs of caves formed by the solution of rock salt, rock gypsum, anhydrite, or other soluble material by percolating underground water either as ordinary descending ground water or deep-

seated artesian water (Frye and Schoff, 1942, p. 39). The Sharon Springs cave-in and Old Maid's Pool in Wallace County are true sink holes. Frye (1945, p. 31) following Johnson (1901, pp. 703-704) believes that some of the High Plains depressions are due to the combined effect of mechanical compaction of the ground particles and chemical solution of the more soluble particles at the sites of the depressions. The agent involved is rain

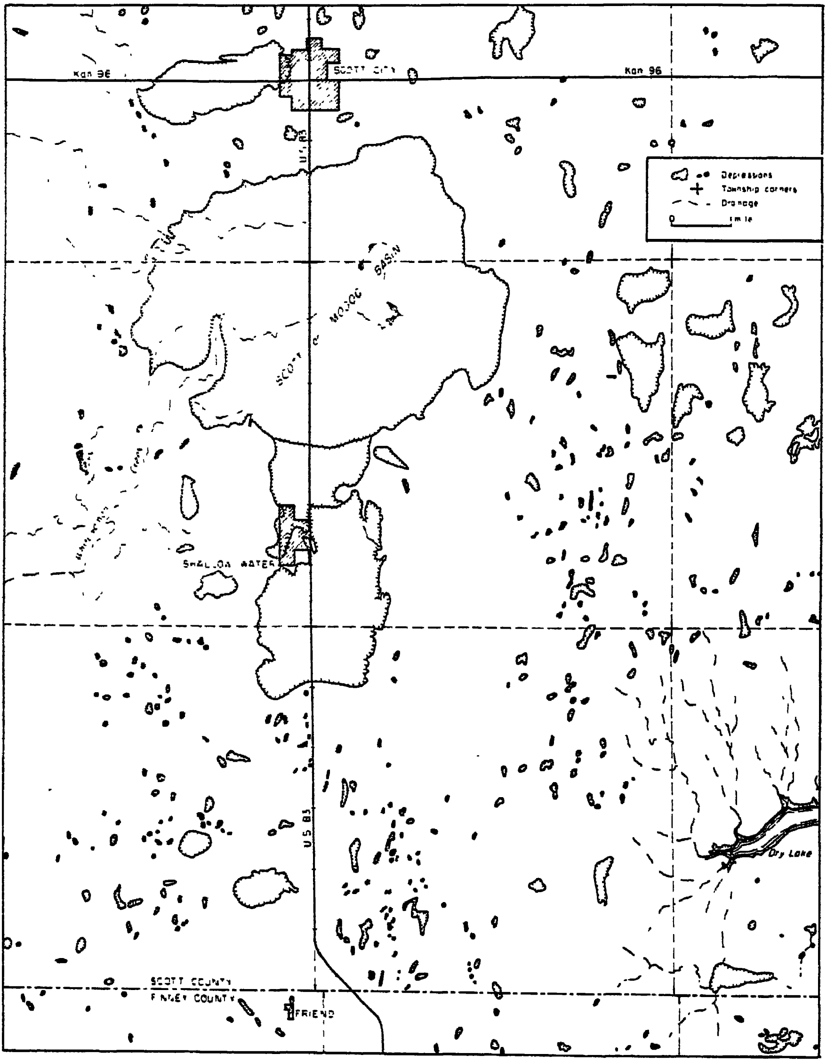


Fig. 47. Map showing characteristic depressions dotting the High Plains surface in Scott County, Kansas. (U.S.G.S. Scott City Quadrangle)

Fig. 48. Meade "salt sink." Sink hole 1½ miles south of Meade, Meade County, Kansas. Some of the larger depressions on the High Plains surface are typical sink holes. (Courtesy State Geological Survey of Kansas; Frye, 1942; Photograph by W. D. Johnson)

water impounded in initial faint unevenesses of the High Plains surface which percolating downward causes the unconsolidated materials to settle appreciably beneath the basins. Still another explanation for the depressions is to be found in the uneven distribution of sediments at the time when they were deposited—i. e., the depressions are initial irregulaities on a depositional surface. Russell (1929) is of the opinion that the depressions in Wallace, Logan, and other counties in western Kansas are related to the formation of large caverns in the chalk beds by tensional faulting. The weakening of the roof of the cavern finally causes it to collapse giving rise to the surface depression. Some shallow depressions may probably also be explained as wind excavated cavities (Evans and Meade 1945, p. 490). Since the depressions dot the surface of the High Plains by the thousands it is not unreasonable to assume that perhaps all the explanations offered for their origin are tenable, and that perhaps the hypothesis offered by Russell is least applicable but may account in exceptional cases to explain localized depressions.

Entirely of a different nature, origin, and size are the Scott-Finney and Meade Basins. The Scott-Finney Basin is a broad, shallow, and irregular basin 4 to 8 miles wide and 25 to 30 miles long extending southward from a short distance south of Scott City in Scott County to approximately Arkansas River in Finney County. Topographically the basin is continuous with the Arkansas Valley toward which its surface slopes but to which it has no surface drainage (Smith, 1940, p. 19). This elongated topographic depression is asymmetrical in cross section with its eastern margin more marked and abrupt than its western border. In Finney County (Latta, 1944, p. 72) the eastern limits of the basin are marked by a conspicuous escarpment 50 and more feet high. To the west the surface slopes upward gradually merging with the upland surface of the High Plains. The basin is without surface drainage. Whitewoman Creek and numerous short drainage courses enter the basin from the west only to become "lost streams disappearing in the porous sands and gravels several hundred feet thick filling the basin. The floor of the Scott-Finney Basin is uneven and is dotted with a large number of minor depressions including the Scott-Modoc Basin described elsewhere in this paper. According to Smith (1940, pp. 138, 145) the Scott-Finney Basin is a structural feature, a post-Ogallala downwarp along an axis trending roughly north-south.

A second large basin is the Meade Basin or Trough. This basin, both a topographic and bedrock depression, is about 30 miles long, trends north-northeast through Meade County and extends for some distance into southern Gray County and into the southwest corner of Ford County.

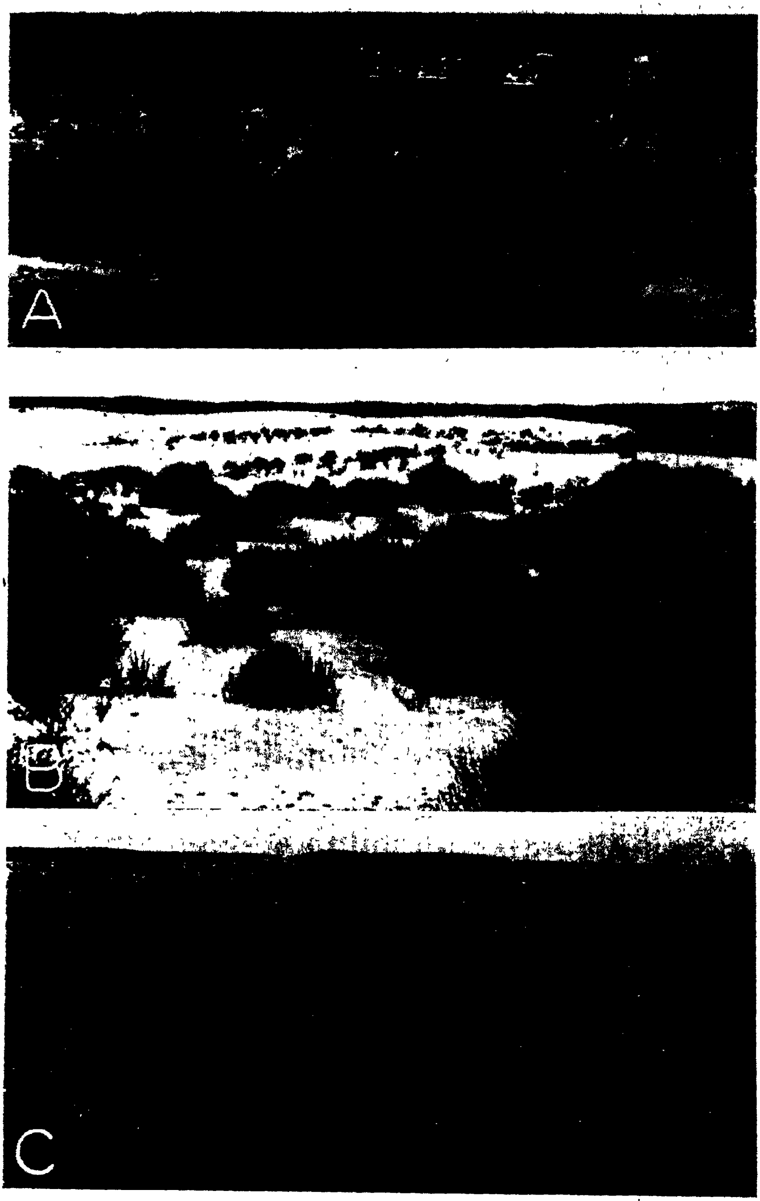


Fig. 49. High Plains features. (A) Sink hole 11 miles south of Coolidge at SE¼ sec. 15, T. 25 S., R. 42 W., Hamilton County. (B) Sand drifts invading field in sec. 22, T. 25 S., R. 38 W., Kearny County (C) Dune ridge 9 miles southeast of Kendall, Kearny County, Kansas. (Courtesy State Geological Survey of Kansas; McLaughlin, 1943; Photographs by H. T. U. Smith)

Today the Meade Basin is drained by Crooked Creek. The Meade Basin is of great hydrologic importance and is the only artesian basin of appreciable extent in the State. Several hundred flowing artesian wells are furnishing water in the basin today. The Meade Basin is explained partly on the basis of downwarping, faulting, stream erosion, and deposition, and the solutional work of underground waters (Frye, 1942, pp. 22-23; Smith, 1940, pp. 145-146).

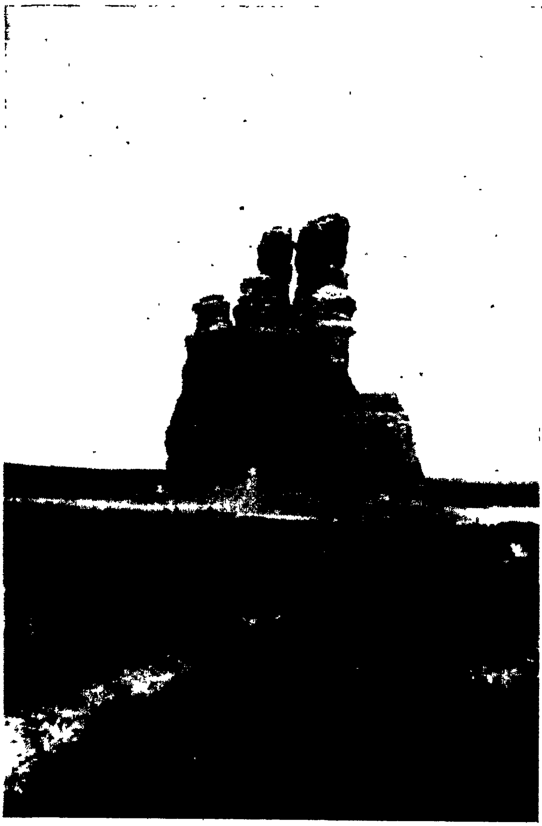


Fig. 50. Castle Rock, a chalk spire about 70 feet high in eastern Gove County, Kansas. See Figure 54 for location.

In addition to the numerous depressions and large basins which characterize the High Plains topography, low sand dunes (Fig. 49 B and C) add local relief to the otherwise flat to slightly undulating plains surface. The largest upland sand-dune area is south of Cimarron River in Morton, Stevens, and Seward Counties (Fig. 36), an area designated by Smith (1940, pp. 127-128) as the Cimarron Bend section.

Fig. 51. High Plains scenery. (A) Approach to the Monument Rocks with the Sphynx in the foreground. (B) The Sphynx, a Cretaceous chalk monolith approximately 35 feet high. (C) Monument Rocks, taken from the south end looking north. The Monument Rocks are in western Gove County, Kansas. See Figure 55 for location.

Fig. 52. Detailed views of the Monument Rocks, western Gove County, Kansas.

Geologically the High Plains are for the most part underlain by Tertiary (Ogallala) and Quaternary deposits (Fig. 12), most of which are unconsolidated or poorly cemented. Cretaceous chalk and shale formations form the bedrock in a strip of country in and bordering the Smoky Hill River Valley.

Erosional features of unusual scenic interest have been developed in the chalk beds of this physiographic unit. Castle Rock (Fig. 50), the Sphynx (Fig. 51B), and Monument Rocks (Figs. 51 and 52) all in Gove

County are notable examples, as are also the Pyramids in Gove County, the Bad Lands (Fig. 53A) about 3 to 4 miles west of Elkader in Logan County and numerous chalk-lined canyons (Fig. 53B). Figures 36, 54, and 55 serve as a guide to direct the interested traveler in finding these unusual erosional chalk remnants and scenery.

The Ogallala formation is essentially a stream-laid deposit consisting of silt, sand, gravel, and minor amounts of clay. Volcanic ash, limestone beds, and some scattered deposits of chert are present locally. Much calcium carbonate in the form of caliche is present also. The deposits are from 50 to possibly more than 500 feet thick and for the most part are poorly cemented or entirely unconsolidated. Where cemented the deposits are more resistant to weather and erosion and usually stand out in the form of benches or low banks or cliffs. The cemented portions of the Ogallala are commonly called the "mortar beds." The deposits are clearly water-laid as is indicated by their variable character both laterally and vertically. The coarser materials consist of sandstone, ironstone, quartzite, and crystalline igneous and metamorphic rocks. Structurally, the sands and gravels show all degrees of structure from even bedded to irregularly cross bedded and nonbedded. Channeling and cross bedding are very common.

The High Plains sands, gravels, and silts were formerly believed to be lacustrine or lake deposits (Hay, 1890, pp. 45-47; Williston, 1895, pp. 213-214) but are now definitely attributed to be of fluviatile or river origin. According to Smith (1940, pp. 78, 80) these Tertiary deposits are a warped and dissected piedmont alluvial plain deposit, not, however, of the composite fan type. The sediments were deposited on a partially developed peneplain which extended from central Kansas westward to the Rocky Mountain front. As shown by Frye (1946, p. 71) the flat upland surface of the High Plains is not the original surface developed by stream deposition during Ogallala time and kept essentially unchanged throughout Pleistocene and Recent time because of a protecting cover of short grass, a view held by many geologists (Haworth, 1897; Johnson, 1901, p. 629; Adams, 1903, p. 122; Fenneman, 1931, pp. 11, 107). According to Frye (1946, p. 73), "There are many indications, however, that the area has been extensively modified by several cycles of erosion and deposition since Pleistocene time, and it seems clear that most of the present Hight Plains surface was shaped in late Pleistocene and Recent times. The stratigraphy and structure of Tertiary and older rocks has exerted an influence on the Quaternary history of the central High Plains. . . ." The nearly flat alluvial plain developed in late Tertiary time was considerably dissected during Pleistocene time, stream valleys were filled,

drainage patterns were extensively modified, faulting occurred, solution-subsidence depressions were developed, other basins and depressions were formed and filled, sand dunes were built, and wind-blown silt and loess was widely distributed over the High Plains area. All of these factors

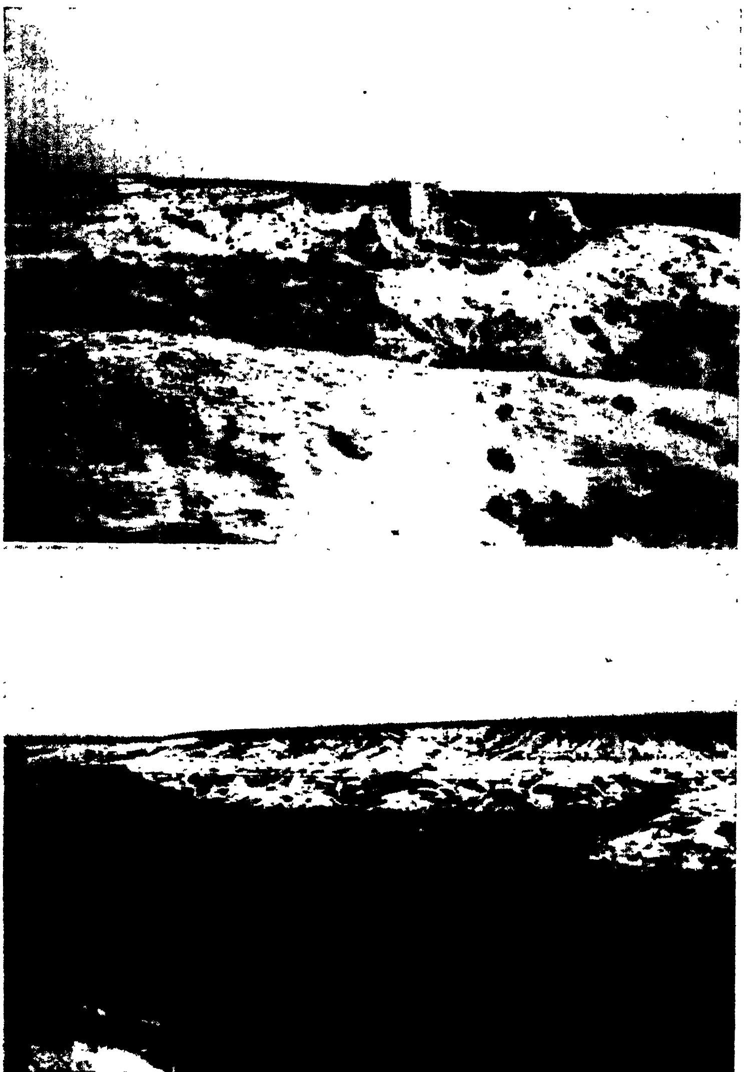


Fig. 53. High Plains chalk country scenery. (A) Bad Land topography 3 to 4 miles west of Elkader, Logan County. (B) Canyons cut in the Cretaceous chalk beds along Smoky Hill River west of Elkader, Logan County. See Figure 55 for location.

together with weathering and dissection of Recent times are responsible for the present High Plains surface (Frye, 1946, p. 84).

Wheat farming and stock raising are the chief industries of the High Plains. Alfalfa, sugar beets, melons, and grain sorghums are important crops locally. Natural gas, volcanic ash, and sand and gravel

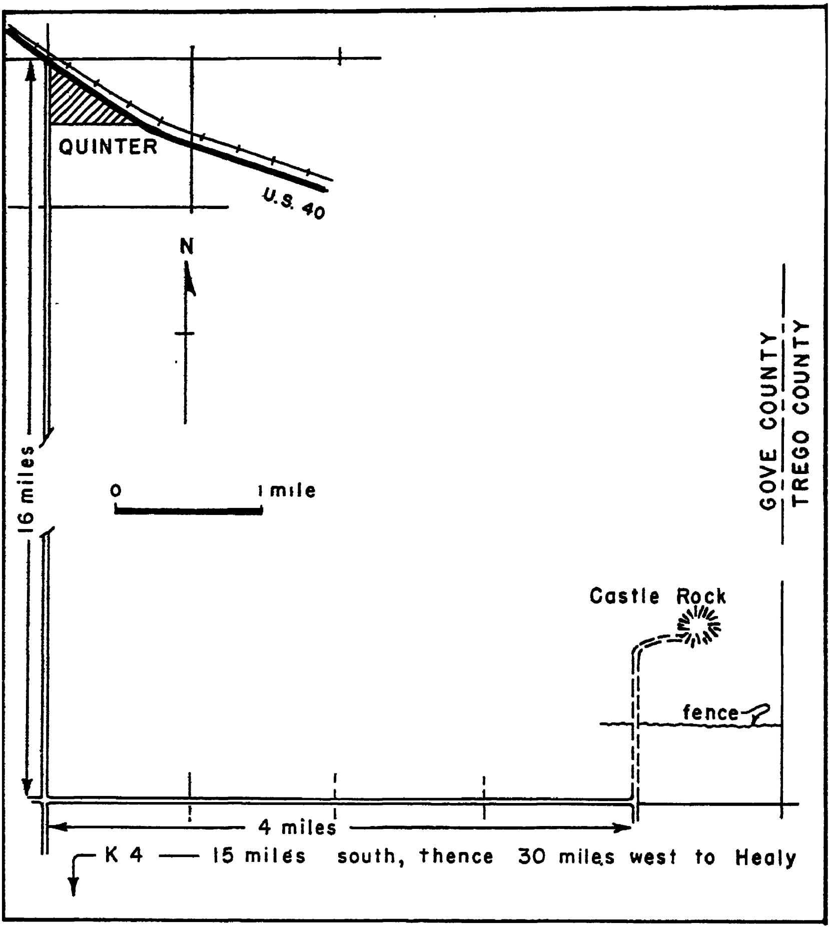


Fig. 54. Map showing location of Castle Rock in eastern Gove County, Kansas.

are the chief mineral resources of this part of Kansas. Many fine specimens of fossil swimming reptiles, plesiosaurs, ichtyosaurs, and mosasaurs, have been collected from the chalk beds of this section of the State (Lane, 1946).

Liberal (7,297), Goodland (3,721), Colby (3,119), Norton (2,938), Phillipsburg (2,570), Scott City (2,358), and Ellis (2,068) are

cities of the High Plains with populations each of more than 2,000. Other important towns include Atwood, Caldwell, Coldwater, Dighton, Hill City, Hoxie, Hugoton, Johnson, Leoti, Meade, Ness City, Oakley, Oberlin, Richfield, Russell Springs, St. Francis, Sharon Springs, Smith Center, Stockton, Sublette, Tribune, Ulysses, and Wakeeney.

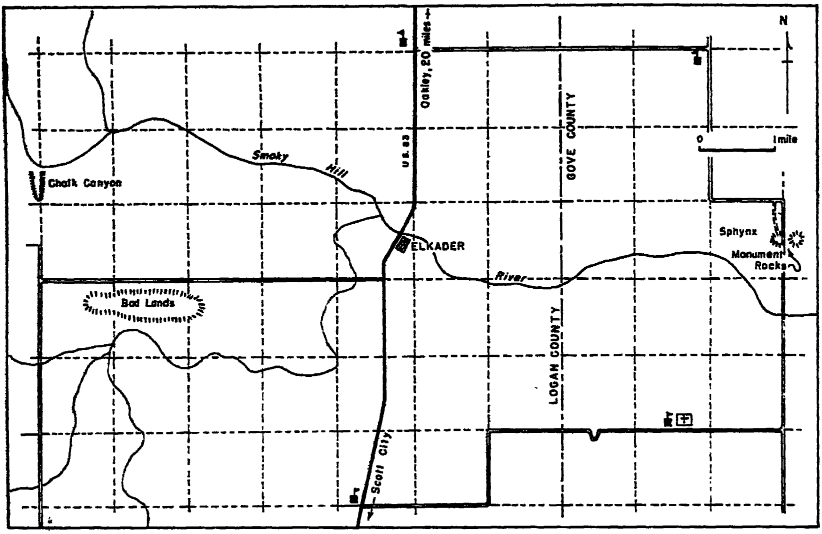


Fig. 55. Map showing locations of Monument Rocks and the Sphynx in western Gove County and the Bad Lands and chalk canyons in Logan County, Kansas.

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The Editor's Page

Transactions
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ROBERT TAFT, *Editor*

Late in the summer the editor made a two day visit to the University of Michigan Biological Station in northern Michigan, some twenty-five miles from the Straits of Mackinac, and was greatly impressed by the Station and its work. An extensive and adequate, but not elaborate, plant which will care for over two hundred persons is maintained in a region rich in biological material. Most of the work offered in the eight weeks' session of the Station is strictly field work. In general, mornings are spent in collecting material over wide and diverse areas. In the afternoon, the collections are classified and studied in the laboratories.

Doubtless this method of instruction would receive the wholehearted commendation of the elder Agassiz, that dynamic and forceful character who has greatly influenced methods of teaching the biological and geological science. In fact, as nearly as the editor can determine, Agassiz is to be regarded as the originator of the biological station idea in America. In the summer of 1873, with the financial aid of a New York friend, he organized on the island of Penikese in Buzzard's Bay (Massachusetts), a study group of some fifty personally selected students. Agassiz chose these students from many applicants, partly to secure a wide geographic distribution and partly to secure students of widely varied interests. Many in that group later achieved marked distinction in various scientific fields. In this first American biological station, a barn served as dining hall and lecture room. To be sure, a new floor had been added but, according to David Starr Jordan, one of the Agassiz students at Penikese "the swallows' nests were undisturbed under the eaves. The sheep had been turned out, the horse-stalls were changed to a kitchen, and on the floor of the barn, instead of a hay-wagon, were placed three long tables. At the head of one of these sat Agassiz."

Unfortunately the effort at Penikese came late in Agassiz' life for he died in December following the summer spent on the island. His son, Agassiz, the younger, carried on at Penikese the summer of the following year but the vitality of the elder Agassiz was lacking and the station did not open in the summer of 1875. Of particular interest to Kansans, however, is the fact that Frank H. Snow, professor of natural sciences at the University of Kansas, was a student at Penikese in 1874 and no doubt the reflected influence of Agassiz and

Snow's experiences on the island contributed to Snow's marked success as a teacher.

Although Penikese was abandoned after 1874, other institutions were established following the example laid out by Agassiz. Johns Hopkins University opened a seaside laboratory modeled after Penikese in the summer of 1878; the famed Woods Hole Marine Laboratory began in 1888. Since that time a considerable number of biological stations have been established both on coastal waters and on fresh waters. The Michigan Station is one of the oldest of the fresh water stations, having held its initial session in the summer of 1909. Here again we have interesting Kansas connections for Dr. Frank C. Gates of Manhattan, an associate editor of these *Transactions,* and Dr. H. B. Hungerford of Lawrence, have been instructors in the Michigan Station almost since its opening.

All of which leads us to ask "Is there any need for a biological station on the Great Plains?" It is true that the University of Wyoming conducts a summer science camp but it is located in the Medicine Bow Mountains at an elevation of 9500 feet and while Great Plains fauna and flora are available for study they occur at elevations far above that found on the typical Great Plains east of the mountains.

Just this past summer Messrs. Horr and McGregor of the University of Kansas made extensive and valuable collections of western Kansas flora; but their collecting necessitated first a trip to western Kansas and then return to Lawrence to care for their material; then return to the plains and back again with frequent repitition.

A biological station would enable such students to make more adequate surveys of plant and animal life of the Plains as well as to offer students from here and elsewhere an opportunity to become acquainted with new and different biological materials and processes. Are Kansas schools overlooking an important adjunct to their programs? Possibly the establishment of a Great Plains Biological Station would provide an excellent opportunity for a joint effort by Kansas colleges and universities. May we have an expression of opinion from the biologists of the state?

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication dates, namely the fifteenth of March, June, September, and December.

Not since 1945 has the Academy put on an intensive membership campaign, and many changes and additions to the roster of scientific personnel in the state have taken place in the past four years. Many of these new additions are not members of the Academy; some in fact, probably do not know there is such an organization. A systematic canvass of the scientific staff at each college and institution in the

state should reveal that there are a considerable number of prospective members of the Academy. We are, therefore, appealing to the representatives of each institution to appoint a member or members to undertake an intensive local membership campaign. Application blanks may be secured by writing the secretary, Dr. A. M. Guhl, Kansas State College, Manhattan, or the managing editor of the *Transactions*, Dr. W. J. Baumgartner, University of Kansas, Lawrence.

The 82nd annual meeting of the Academy will be held at Wichita on April 13, 14 and 15, 1950. Put the dates down on your calendar.

Dr. Paul G. Murphy, president of the Academy and dean of students and professor of psychology at Kansas State College, Pittsburg, has announced his resignation from the College to accept a position as clinical psychologist with the firm of Conwell, Street, and Kurth, physicians of Wichita. Dr. Murphy began his new duties October first.

Dr. Emmet C. Stopher became head of the department of mathmatics at Fort Hays Kansas State College at the beginning of the current school year. Dr. Stopher received his training at Miami, Kent State, and Iowa State Universities. He comes to Hays after some years teaching experience at Miami University, Oxford, Ohio, and elsewhere.

Dr. H. B. Hungerford, for the past twenty-five years head of the department of entomology, University of Kansas, Lawrence, resigned his position as departmental head on July first in order to devote his time exclusively to research and teaching. Dr. Hungerford was succeeded by Dr. Charles D. Michener, who joined the University staff in the fall of 1948. Dr. Michener, who received his training at the University of California, came to the University from the American Museum of Natural History, New York City, where he was associate curator of lepidoptera.

Professor E. E. List has resigned his position as a member of the Ottawa University biology staff to become professor of geology at the College of Emporia. Professor List was succeeded at Ottawa by John A. Bacon, who is completing his work for the doctorate in entomology and zoology at the University of Kansas.

Dr. Robert W. Baxter has been added to the botany staff at the University of Kansas as assistant professor. Dr. Baxter received his Ph.D. during the summer at Washington University, St. Louis, in the field of paleobotany. Dr. Baxter served for five years during the war in the naval air force and left the service with the rank of lieutenant commander.

Dr. Howard E. Evans joined the staff of Kansas State College, Manhattan, on September first, as assistant professor of entomology. Dr. Evans received his training at Cornell University and has made an extensive study of the spider wasps. Dr. Evans fills the place left vacant by the retirement of Dr. George A. Dean.

Mr. T. Richard Young has been added to the staff of the University of Wichita Foundation for Indus-

trial Research as field engineer. Mr. Young received his training at the University of Michigan and has had industrial experience with the Texas Company and Lubrication, Inc., of Rochester, New York.

Dr. W. H. Schoewe of the University of Kansas and associate editor of the *Transactions*, completed field studies on the cretaceous lignite deposits of central Kansas during the summer. The week of August 22, he served on the teaching staff of the state 4-H conservation camp at Rock Springs Ranch southwest of Junction City in the Flint Hills. The previous week he gave a short course in geology to members of the 4-H clubs of Wallace, Scott, Logan, Kearney, and Hamilton Counties at Camp Cristy on the Scott County State Lake. Dr. Schoewe was recently elected lieutenant-governor of division five of Kiwanis International for the Missouri-Kansas-Arkansas district. Division five comprises 12 counties in the northeastern part of the state.

Mr. A. C. Carpenter of Ottawa and a member of the Academy Executive Council, gave an illustrated lecture before the September meeting of the Flint Hills Geology Club, Kansas State College, Emporia. Mr. Carpenter's lecture included a report on the second annual meeting of the American Association of Mineralogists held in June at Sacramento, California, and to which Mr. Carpenter contributed a paper on selenite crystals. Mr. Carpenter also showed an extensive series of colored views taken on a six weeks' vacation tour of the western states.

Mr. J. E. Robinson came from Washington University, St. Louis, at the beginning of the current school year to take a position on the staff of the physical science department at Kansas State College, Emporia. Mr. Robinson replaces Mr. John Zimmerman, who is now on the faculty of the University of Colorado, Boulder.

Professor J. M. Berkebile of Mcpherson College is still on leave of absence at Ohio State University where he is completing his work on the doctorate in chemistry. Dr. L. V. Heisey, who is acting head of the chemistry department at McPherson during Professor Berkebile's absence, has continued his investigations at McPherson on vinyl derivatives of five atom heterocyclic rings and with G. Bryant Bachman published a report of these studies in the June issue of the *Journal of the American Chemical Society*.

The insect collection of the department of entomology, Kansas State College, Manhattan, was moved this summer to the third floor of Fairchild Hall. Following the burning of the chemistry building at Manhattan several years ago, the collection was placed in a specially built fire-proof vault in the basement of Fairchild. Deterioration of specimens from dampness and lack of accessibility led to the decision to risk the fire hazard and to move the collection. It is now readily available for making additions, modernizing nomenclature and for use by advanced students.

Dr. Alfred F. Glixman, assistant professor of psychology at the University of Mississippi for the past two years, has been added to the psychology staff at the Univer-

sity of Kansas, Lawrence. Dr. Glixman received his doctorate from the University of California in 1947. Also added to the University psychology staff as instructors were Messrs. J. W. Bowles, Howard Perlmutter, Kenneth Runyon, and William Thompson.

Mr. Merle L. Brooks, instructor in biology at Kansas State College, Emporia, spent the past summer working on his doctorate at the University of Colorado, Boulder. Mr. Brooks is making a study of cladocera in the natural waters of Kansas.

Dr. W. H. Schechter of the chemistry staff at Sterling College has resigned his position to accept an appointment on the research staff of the Mine Safety Appliances Company, Pittsburgh, Pa.

General Chemistry, A Systematic Approach, (The Macmillan Company, N. Y. $5.00) by Messrs. Sisler, Davidson, and VanderWerf has just come from the publishers as we go to press. The 870 page book is designed for the beginning year's work in college chemistry. Professor Sisler is now a member of the Ohio State University staff, Columbus, and Professors Davidson and VanderWerf are well-known members of the chemistry department staff at the University of Kansas.

The late Dr. G. E. Coghill, for some years head of the department of anatomy at the University of Kansas and an active member of the Academy during his residence in Kansas, has recently been honored by the publication of his biography. Dr. Paul G. Roofe, present chairman of the anatomy department at the University, reviewed the Coghill biography for Academy members and we are pleased to present Dr. Roofe's review below.

George Ellett Coghill, Naturalist and Philosopher. By Judson Herrick, the University of Chicago Press, Chicago, 280 pp., frontispiece, 1949, $5.00.

There are few instances in the history of science where one finds a whole system of a science developed by one man, who not only conceived the ideas, but who ingeniously devised techniques for their coming into being. George Ellett Coghill, a philosopher at heart, became deeply concerned with the science of psychology. He soon discovered that the basic underlying foundation of behavior rested in the neural structures and their relations with the rest of the body. Reflexology was not the clue. As a naturalist, he sought the origins of overt behavior. As a scientist, he selected carefully the objects of his choice, namely; the ontogeny of behavior in the first land vertebrate. By carefully observing embryonic behavior in larval forms of a tailed amphibian (Amblystoma tigrinum), he discovered how, out of general body behavior, discrete, individual patterns of movement came into being.

His findings clearly show how nature builds her creatures to behave as a whole from their very beginning. Animals develop in a very orderly manner; their behavior is not a collection of separate and discrete movements of individual parts. Out of a total body pattern of behavior the movement of parts, such as the arm or leg individuate and become discrete, but at all times being subject to the whole organ-

ism. This simple finding had great implications, for studying further in development, one sees more clearly how mentation itself comes into being. We see things at first as wholes and then their distinctive parts.

This book is indeed unique. It is, because Herrick wrote it. It is unusual because it portrays science as lived and produced by a man whose "philosophy, like his psychology, was dynamic and naturalistic . . .' a philosophy, not of being but of becoming; not of life, but of living'."

In book one, a very intimate biography of Coghill is presented. It gives clearly the success achieved by a great scientist who labored under hardships that were almost insurmountable. These hardships were intertwined with frustrations and considerable limitations.

It is most unusual to find a biographer whose life is so clearly associated with the person of whom he writes. Professor Herrick describes Coghill's method in Book Two. Probably no other person could portray this scientific method as well as the author, for the two worked together for over forty years; the work of each complementing that of the other.

The third part of this book is indeed unique. It comprises a collection of hypothetical dialogues between Coghill and Herrick. It is an excellent attempt to present Coghill's philosophy based upon fragmentary notes, personal contacts and letters. As Herrick himself admits, it might be as much Herrick as Coghill.

Coghill presented to the scientific world a new conception of behavior. This was not a theory but an idea based exclusively upon observed structures in their relation to behavior. His conceptions were admirably presented in a monograph—"Anatomy and the Problem of Behavior."

Coghill lived his science. He always stressed the humanistic values. There is one enduring theme in this book, namely: the representative man of science must work for human values in whatever field he applies himself. Coghill did just that.

Dr. N. P. Sherwood, head of the department of bacteriology, University of Kansas, retired from his administrative duties with the beginning of the current school year, but will continue as professor of bacteriology. Dr. Sherwood was succeeded as departmental chairman by Dr. Robert Guthrie who came to the University after several years' work with the National Institute of Health, Washington, D. C. Dr. Guthrie received doctorates both in medicine and in bacteriology from the University of Minnesota.

Professor Karl Stacey of Kansas State College, Manhattan, is on leave during the present school year in order to complete the requirements for his doctorate in geography at Clark University, Worcester, Mass. During Professor Stacey's absence, Mr. Harold Metz has joined the Manhattan staff as temporary instructor. Professor O. W. Tollefson, also of Manhattan, is likewise on leave of absence in order to complete his doctoral studies at the University of Colorado.

Mr. Edwin P. Margerum, Jr., a graduate of Pennsylvania and Mich-

igan State Colleges, has joined the department of animal husbandry of the Manhattan school. Mr. Margerum will hold the rank of assistant professor in the department and will be engaged in problems of meat research.

The past summer saw the death of a number of our members, including several of long standing. We deeply regret to announce their passing.

Dr. Arthur W. Barton died in Kansas City, Kansas, on September first. Dr. Barton for fourteen years was professor of biology at Fort Hays Kansas State College before his retirement in 1943. Dr. Barton joined the Academy in 1928 and during his professorship at Hays was active in Academy affairs.

Dr. Henry J. Harnly, one of the Academy's oldest members, died in McPherson, Kansas, on August 26, 1949, at the age of 87 years. Dr. Harnly served McPherson College for 42 years in the capacity of professor of biology, dean, vice-president and acting president. He was president of the Kansas Academy of Science, which he joined in 1893, during the year 1926-27.

Mrs. Marion Campbell Giblin, a life member of the Academy since 1929, died in Topeka, Kansas, on September 16, 1949. Mrs. Giblin for some years had been a member of the staff of the Topeka State Hospital.

Mr. R. C. Yapp, assistant state entomologist, died in Manhattan on September 10, 1949. Since 1927, Mr. Yapp had been employed by the Kansas Entomological Commission as entomologist for the northern half of Kansas.

Dr. Edwina Cowan, consulting psychologist of Wichita, and a life member of the Academy since 1929, died on June 13, 1949. Dr. Cowan, with her husband, was killed in the crash of a private plane near Wichita.

Dr. Edwin C. Miller, professor emeritus of plant physiology at Kansas State College, Manhattan, since 1945, died at the home of his daughter near Superior, Nebraska, on August 2, 1949, at the age of 71 years. Dr. Miller achieved national and international distinction in his field during his active teaching years at Kansas State which extended from 1910 until his retirement in 1945. Dr. Miller was a life member of the Academy which he joined in 1918. Readers of the *Transactions* will find a more extended biographical account of Dr. Miller in the issue of *Plant Physiology* for August 14, 1945, published at the time of his retirement.

Miss Ada Swineford, who has been on leave of absence the past two years, returned to her duties this fall as geologist for the State Geological Survey, Lawrence. Miss Swineford has held a research fellowship at Pennsylvania State College during her leave and has been studying the properties of clay minerals by means of X-ray and electron microscope examination.

Mr. Courtenay D. Anselm joined the staff of Fort Hays Kansas State College at the beginning of the school year as instructor in chemistry. Mr. Anselm received his master's degree in chemistry at the University of Washington.

Dr. R. H. Painter, professor of entomology at Kansas State College, Manhattan, who has been on sabbatical leave the past year, returned to his position on August first. Dur-

ing his leave he completed the manuscript of a prospective book *Resistance of Plants to Insect Attack.*

Dr. Dorothy Simrall and Mr. Ralph Wright have been added to the staff of the phychology department, Kansas State College, Pittsburg, Dr. Simrall, a graduate of Iowa State University, has been teaching at Tulane University. Mr. Wright goes to Pittsburg from the Northwestern University where he has been working on his doctor's degree.

Dr. Gordon H. Svoboda, who recently received his doctor of philosophy degree from the University of Wisconsin, has become assistant professor of pharmacy at the University of Kansas. In recent years, Dr. Svoboda has made extensive studies in the chemistry of volatile oils. Other new additions to the staff at the University School of Pharmacy are Mr. Jack L. Beal and Mr. Dallas W. Ruehlen, instructors.

Dr. Roger C. Smith, professor and head of the department of entomology, Kansas State College, Manhattan, was elected president of the Central Plant Board. Dr. Smith is one of a committee of two to prepare a plant inspector's manual to be submitted at the next meeting of the Central Plant Board in Kansas City on March 21, 1950.

Mr. Horace C. Traulsen, a member of the Academy since 1943, has been in the Far East for the past three years. Most of this time he has been in China but more recently, with his wife, he has been living in Manila. Still more recently he has been in Borneo but he expects to return to Manila shortly.

The department of geology at Kansas State College, Manhattan, continued the mapping of engineering construction materials in the state during the past field season. Geologic maps and inventories of materials were compiled for Nemaha, Osborne, Sheridan, and Rawlins Counties. Similar work has been started in Pottawatomie County but is not yet complete. This project is one of cooperation between the U. S. Geological Survey and the geology department of the State Highway Commission. As in the past, the program is coordinated with that of the State Geological Survey.

Dr. L. D. Wooster, president of Fort Hays State College, retired during the past summer and has become president emeritus. Dr. Wooster has been a member of the staff of the Hays institution for forty years, the past eight years as president. Dr. Wooster's successor, Dr. M. C. Cunningham, formerly dean of Northwest Missouri State College, Maryville, was inaugurated as president of the college on September 30.

An interesting investigation on mammalian reproduction involving dogs as experimental animals has recently been initiated at Kansas State College, Manhattan. The project, under the joint direction of Dr. H. T. Gier of the zoology department and Dr. W. M. McCleod of the school of veterinary medicine, is aimed toward the elucidation of various factors involved in normal mammalian reproduction and the accumulation of data for a comprehensive report on the embryology of the dog.

Junior Academy News

Items for this column are invited from all Junior Academy sponsors and members. For inclusion in any given issue they should be sent to the Junior Academy editor, Miss Edith Beach, 812 Illinois Street, Lawrence, Kansas, at least three weeks before our publication dates, namely the fifteenth of March, June, September, and December.

The Junior Academy of Science committee members are: Margaret Parker, K.S.T.C., Pittsburg, chairman; Ralph Rogers, Manhattan H. S.; J. A. Brownlee, Wichita East H. S.; Edith Beach, Lawrence H. S.; Donald Parrish, K.S.C., Manhattan; Gladys Beck, Wyandotte H. S., Kansas City; Mrs. C. G. Crockett, Yates Center H. S.

For information concerning club activities, sponsors may write to any of the above committee members.

What is your science club doing for the community? Please send in answers to this question for publication in the next issue. Other clubs would like to know. Also, club members over the state are always in need of interesting and worth while science projects. Won't you send in descriptions of such projects to the Associate Editor, 812 Illinois Street, Lawrence?

Is your club a member of the Kansas Junior Academy of Science? If not, JOIN. Let's put our state academy foremost among the many state academies. Get demonstrations or papers ready for the state meeting of K.J.A.S. to be held in Wichita next spring. Write to Miss Parker for information regarding the state meeting.

How many of the seniors in your club are planning to enter the Science Talent Search? Let's have more entries from Kansas. Get busy on a project, write an essay on the subject and take the examination before December 27. Win a scholarship or a trip to Washington, D. C.

At the annual meeting of the Kansas Junior Academy of Science at Manhattan in May the judges rated as the two outstanding numbers a talk by Mervyn Brillhart of Labette County Community High School, titled "Atomic Energy," and a demonstration by Norma Jean Barbero of Pittsburg Senior High School titled "Some Early Spring Flowers."

In his talk Mervyn Brillhart traced the development of the use of atomic energy, discussed briefly the theory of use of atomic energy, and in closing appealed to man to control atomic energy intelligently. Norma Jean Barbero displayed and identified more than fifty varieties of early spring flowers.

EXHIBIT NOTES
(Manhattan Meeting)

The group exhibit was the best in several years, and was well divided between the fields of physical and biological science. Pittsburg was awarded first place with a very fine, well diversified exhibit. Lawrence Junior High and Wichita East High School were awarded second and third places respectively. The general sweepstake award was given to Pittsburg, with Wichita East and Manhattan rated as second and third. Norma Jean Barbero of Pittsburg was rated as the out-

standing individual of the meeting.

At the annual election, Richard Comstock of Pittsburg High School was elected president and David Horr of Lawrence Junior High was elected secretary.

John Feist and Tommy Pearson arranged three boxes containing earth and plaster to illustrate methods for tracing prints. One box had a footprint, another, the plaster cast of the print, and the next the shoe in comparison with the cast.

Another box contained a block of wood with a hammer print. Arrows indicated the method for telling the direction of the blow and the weapon used.

Gary Floyd took and developed pictures of field trips which he had attractively arranged.

A collection of plant fossils from the Lone Star area was arranged by Dorothy Pickel and Ellen Sellers. The fossils were collected on a series of trips and identified and labelled by the girls.

Rodney Laas and John Wulfkuhle collected, identified and labelled animal fossils. The fossils were placed in shallow specimen trays.

Chris Snyder was fortunate enough to take several trips to Florida where he collected mollusks. Chris built cases, identified and labelled his collection.

Rodney Ernst and Eddie Martin prepared a collection of rocks and minerals, obtained from all parts of the U.S. This collection represented a two-year project. Many specimens were collected on summer trips and identified during the winter.

An insect collection by Robert Reiter was outstanding. His collection was so extensive that he brought only his moths, butterflies and beetles.

Don Springer constructed a plaster model of a fault. One model showed the beds before displacement and another model represented the same area afterwards.

Reports presented at the annual meeting of the Junior Academy will be published from time to time in these pages. In the June issue we published one by David Horr of Lawrence on snakes and in this issue, two additional reports by Messrs. Nyberg and Debusman are honored by publication. If you wish your report published be sure to turn it in at an annual meeting, taking care to see that it is clearly and plainly written and that any drawings to be included are carefully made. Diagrams drawn in free-hand cannot be used.

The Colloidal State

Wayne Nyberg
Clay Center High School

In 1861 a Scottish scientist named Thomas Graham performed some simple experiments on the passage of certain substances through parchment paper. The substances which passed through the paper, such as sugar and salt solutions, he called crystalloids; but those that did not pass through the parchment paper, he named colloids, from the Greek word meaning "glue-like."

Colloids have several distinctive properties. One method of identifying them is by the Tyndall effect. To demonstrate this effect take two gas bottles; in one place a soluble

salt or sugar solution, and in the other bottle place a gelatin solution. Then pass a strong beam of light through both bottles standing side by side. It passes through the true solution un-noticed, but the beam can plainly be seen in the gelatin solution because of the scattering of light by the colloidal particles.

Another Scottish scientist, Robert Brown, a botanist, in 1827 while examining pollen grains under a microscope, found that they had an unusual movement. Further studies showed that colloidal particles take a zigzag path in solutions owing to the bombardments they receive from neighboring molecules. This effect can readily be seen in an ultramicroscope, and is known as the Brownian movement.

A practical use made of colloids is illustrated in the "Fire Foam" type of fire extinguisher. To demonstrate, take two 400 or 600 ml beakers; into the first one add a small amount of water and about a tablespoon of sodium bicarbonate; and into the second add a small amount of water and a tablespoon of alum powder or acid calcium phosphate together with some powdered gelatin (about a teaspoonful). Pour one mixture into the other, and enough foam should be produced to fill the beaker. It may be rigid enough to remain in the beaker if the beaker is inverted. Very small bubbles of carbon dioxide are held in solution by the film from the colloidal gelatin.

Another industrial use that involves the properties of colloids is that of precipitation of smoke from factories. Formerly, the smoke that came from some factories contained arsenic compounds which are highly poisonous. The wind would blow this smoke for several miles and it would settle on farmers' fields. When livestock ate the grass, they became poisoned, which often resulted in a damage suit against the company.

Mr. Cottrell devised a precipitator, which has helped eliminate the smoke nuisance. The device makes use of a high voltage transformer which precipitates the charged colloidal smoke particles.

In our demonstration we produce the smoke or fog by forcing the fumes of ammonium hydroxide over hydrochloric acid, each being in separate gas bottles. The resulting "fog" of ammonium chloride is then passed into the base of a vertical brass tube about an inch or more in diameter, and about twelve inches high. The top of the tube contains a cork with a hole in the center which permits the smoke to leave when it is not being precipitated. Also from the center of the cork is suspended a small bare copper wire extending down into the brass pipe nearly to the bottom. The wire and the pipe are connected to the secondary terminals of a high voltage transformer, in our case producing 8000 volts. Such an apparatus will precipitate a considerable amount of the "fog."

Directions for Preparing Microscopic Crystals

PAUL DEBUSMAN
Wichita High School East

There are two general methods for preparing microscopic crystals. Both of them depend upon the use of saturated solutions of the substances under consideration.

The first method is to make a hot saturated solution of the substance selected and then allow the solution to cool. To do this, place some of the substance in a Pyrex test tube

and add water. Heat the water until it is boiling. If all the substance dissolves, add more until some of the substance is left on the bottom of the tube. The presence of excess solid indicates that a saturated solution has been made. Then place a drop of the hot liquid on a slide under a microscope and crystals should appear to "grow" from the solution. Some of the substances which can be used in this manner are oxalic acid, potassium nitrate, and barium chloride.

The second method also uses a saturated solution, but a small crystal of the selected substance must be added when the drop of solution is placed on the slide. Some compounds which must be prepared in this way are sodium acetate and sodium hyposulfite (sodium thiosulfate). To prepare sodium hyposulfite for this demonstration, fill a test tube nearly full of the solid substance. Add one or two drops of water and heat till a clear solution is obtained. If done properly, this solution will stay clear for several days. To make the crystals "grow," add a small crystal of sodium hyposulfite to a drop of the solution on a slide under the microscope.

It is often interesting to try mixing two of your solutions. Some of the mixtures will form fine and granular precipitates, but others will produce beautiful crystals. I have not done very much experimenting with such mixtures, but the best combination I have found thus far is a mixture of saturated solutions of oxalic acid and barium chloride. The crystals formed are shaped like stars.

One factor that cannot be stressed too much is cleanliness. *Distilled* water should be used in all cases if possible because city water often contains impurities which spoil the crystals. Slides at all times should be clean and the eye droppers used should be kept in a beaker filled with distilled water.

I realize that these instructions may not answer all your questions and you may find new and better methods of preparing solutions for this purpose.

Kansas Plants New to Kansas Herbaria IV

W. H. HORR and R. L. McGREGOR
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Our field work during the season of 1948 and studies made on our past collections have revealed several of our specimens to represent apparently new records for the state. In addition to our finds we are reporting other new records for Kansas which have been sent in to us or brought to our attention through correspondence. The latter is included in this paper to further consolidate information regarding our Kansas flora.

Carduus acanthoides L. was coll. July 13, 1940, 5 mi. W. of Corning, Nemaha County. A large colony existed for nearly a mile along the side of Kansas highway 9. Several overgrazed pastures in this vicinity also contained large colonies of this species. Rydberg (1932) credits this plant to N.S., N.J., Iowa and Nebr. Our collections would appear to extend the range of the species a little to the southwest.

Polymnia uvedalia L. was collected on Aug. 31, 1948, 6 mi. E. of Baxter Springs, Cherokee County. It was very abundant along the banks of Shoal Creek. Rydberg (1932) listed Kansas in giving the range of this species. Gates (1940) said there was no known specimen evidence for Kansas.

Coreopsis pubescens Ell. was collected on July 31, 1948 6 mi. E. of Baxter Springs, Cherokee County. It was found in small colonies on the wooded, rocky hillsides along Shoal Creek. Britton and Brown (1913) gave the range of this species as Virginia to Illinois and Missouri, south to Florida and Louisiana.

Monarda bradburiana Beck. was coll. July 7, 1940, 3 mi. W. of Severy, Greenwood County. It was abundant in a rocky roadside grassland. Rydberg (1932) and Britton and Brown (1913) listed the plant for Kansas. Gates (1940) says there is no authentic specimen evidence. Stevens (1948) listed the species for the state. It occurs from Greenwood County to Cherokee County where it is abundant.

Cunila origanoides (L.) Britton was coll. on August 30, 1948, 6 mi. E. of Baxter Springs, Cherokee County. The plants were abundant on the rocky, wooded banks of Shoal Creek. The species was not mentioned by Rydberg (1932) though Britton and Brown (1913) gave the range of the species as southern New York to Florida, west to Ohio, Missouri, Arkansas and Texas.

Utricularia gibba L. was coll. on Oct. 3, 1948, from shallow water and mud of Murray lake in Miami County State Park. Rydberg (1932)

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gave the range of this species as Maine, Michigan and south to Texas and Florida.

Sedum ternatum Michx. was coll. on Oct. 9, 1948, 6 mi. E. of Baxter Springs, Cherokee County. It occurred abundantly on limestone outcropping on the banks of Shoal Creek. Britton and Brown (1913) list the species from Missouri. Our collection is apparently the most western record.

Lemna gibba L. was coll. on Aug. 28, 1948 in a small pool below the dam at Lone Star Lake, Douglas County. The plants were restricted to a few small pools of water. This species is known from areas on each side of Kansas.

Mimosa borealis A. Gray has been known by us for several years from Meade County. We now have specimens of this species collected on May 15, 1948 and August 16, 1948 from a prairie hillside just west of the buffalo pasture at Meade County State Park. This station extends the range of the species to the northeast.

Petalostemon pulcherrimus A. Heller was collected on July 4, 1948, 6 mi. E. of Baxter Springs, Cherokee County. It was abundant on a rocky, wooded hillside along Shoal Creek. Rydberg (1932) listed this species for Kansas but Gates (1940) says the specimen was from northeastern Oklahoma.

Passiflora incarnata L. This species was reported by Gates (1940) as occurring in Crawford County in cultivation. We have specimens from Montgomery County collected on July 22, 1942. The plants were growing in sandy open woods, thickets and in fields.

Urtica chamaedryoides Pursh was coll. on April 9, 1941, 9 mi. E. of Parsons, Labette County. A large colony was found in a woods bordering the Neosho River. Britton and Brown (1913) gave the range of this plant as Kentucky to Arkansas, south to Georgia and Texas. Our collection extends the range considerably to the northwest.

During the year we received a collection of plants from Mr. John C. Hancin of Salina, Kansas. A few of these specimens were new to Kansas and are from Saline County. The following are the new records:

Isoetes melanopoda J. Gay Coll. May 20, 1943 from the border of a pond in a cornfield N.W. of Salina.

Rosa bourgeauiana Crep. (det. by K. M. Wiegand) Coll. May 26, 1934, 2 mi. N. of Salina on Ohio St. Road.

Muhlenbergia sobolifera var. *setigera* Scribn. (det. by Agnes Chase) Coll. Sept. 26, 1938 in Kenwood Park, Salina.

Rubus hancinianus Bailey (det. by L. H. Bailey) Coll. May 11, 1943 in a prairie 2½ mi. E. and 5 mi. N. of Salina. This specimen

is from the type locality of the species named in honor of Mr. Hancin by L. H. Bailey.

Rubus oppositus Bailey (det. by L. H. Bailey) Coll. May 4, 1944, 6 mi. S.E. of Salina. Specimens are from the type locality, the species having been described by Prof. Bailey from material sent him by Mr. Hancin.

Several specimens of the Hancin collection represent new distribution records for Saline, Dickinson and McPherson Counties. Those from Saline County are: *Salix interior pedicellata* (Anderson) Ball; *Portulaca retusa* Engelm; *Plantago rhodesperma* Decne and *Solidago altissima* L. A new record from McPherson County consisted of *Helianthus ciliaris* DC. One new record for Dickinson County adds *Salix humulis rigidiuscula* Anders. to the plants known from that County.

Prof. Edgar T. Wherry of the University of Pennsylvania in writing to us has mentioned that he has found a specimen of *Phlox oklahomensis* Wherry, in the herbarium of the New York Botanical Garden, from Cowley County Kansas. This adds another species to our state flora.

In a recent paper of ours, McGregor and Horr (1949), we reported *Selaginella rupestris* (L.) Spring from Chautauqua, Douglas, Elk, Franklin, Greenwood, Johnson, Leavenworth, Montgomery, Neosho, Wilson, Woodson and Wyandotte counties.

In an earlier paper of this series, Horr and McGregor (1947), we reported *Filix bulbifera* (L.) Underw. (*Cystopteris bulbifera* Bernh.) from Wilson, Chautauqua and Montgomery counties. Since our discovery of the plants, which we referred to the above species, we have made other collections in several counties. We now believe our material to be an undescribed variety of *Cystopteris fragilis* Bernh. This contention has been verified by Prof. C. A. Weatherby of the Gray Herbarium. More field work is necessary before we can settle the issue. *Filix bulbifera* (L.) Underw., therefore, should be deleted from our accumulated lists of Kansas plants.

One other correction in our previous papers should also be made. In our paper (1948) we reported *Centaurium calycosum* (Buckley) Fernald from Montgomery County. This plant should have been reported as *Centaurium texense* (Griseb.) Fern. In addition to this report for Montgomery County, McGregor (1948) reported it from Douglas County.

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Botanical Notes: 1948

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"The Unusual Is Usual in Kansas"

We observed and recorded unusual seasonal activities—mostly blooming—of at least sixteen different species of plants. Following several frosts last fall *Oxalis stricta* showed one blossom on November 17. This plant was overabundant in a part of our lawn until discouraged by an anti-weed treatment.

Following a dry spell in late June there was a second period of the germination of the fruits of *Ulmus americana.*

The burning bush, *Cydonia japonica,* the golden bell, *Forsythia sp.*, and the redbud, *Cercis canadensis*, bloomed heavily and with more than commonly vivid colors. Plum trees, both wild and cultivated, and peach trees were lavish with their flowers. In contrast there were but few blossoms on our apple and crabapple trees. There was an excellent crop of peaches. The redbud trees had an unattractive brown color due to the heavy load of fruits.

A black walnut tree on our town property yielded bushels of hulled nuts in 1947. There was an abundance of staminate catkins this year but, by actual count, there were but sixty-two nuts.

Viola pedatifida returned in measurable numbers after a decided scarcity.

We were pleased to find a fair number of plants of *Spiranthes ochroleuca,* a somewhat rare but attractive member of the orchid family. These grow not far from Emporia.

Farmers welcomed a heavy crop of the big bluestem—*Andropogon furcatus.* This grass seeded well also.

Our elm trees were very badly treated. Heavy storms broke off many limbs and even some trees were destroyed by wind. The city had undertaken to spray elm trees for several previous years against the leaf-eating worms, *Paleacrita* and *Aleophila.* This season it was not possible to do this satisfactorily and one result was the denuding of some trees so completely that they were in a bad condition. They appeared also to have been attacked by some kind of fungus; consequently many of the owners have banded their elm trees this season. In addition, the city is spraying the trunks near the ground with DDT. The results will be observed with much interest.

The elms were not alone with their troubles. There was a devastating attack on the walnut and hickory trees by the larvae of species of *Datana.*

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We personally destroyed gallons of these on our home trees and in addition observed many walnut trees quite bare as far south as Greenwood County.

This year records the highest stage of the Cottonwood river ever recorded in Lyon County—29 feet 6 inches. This level is about 10 feet above flood stage. Previous to this flood there was some of the most beautiful and promising corn that one is likely to see. Much of this crop was obliterated and yet more badly damaged, although a portion was saved in the flooded area.

Species of Taphrina in Kansas

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The genus *Taphrina* contains according to a recent revision (Mix, 1949) ninety-eight species, all of them parasitic on higher plants or ferns. One species, *T. deformans,* causing peach leaf curl, is nearly world-wide in distribution, apparently having been introduced into many areas along with its host. It occurs wherever peaches are grown except for a few more arid (and irrigated) regions. Other species, as, for example *T. populina* seem to have been introduced in the same fashion into many new localities but are not so widespread. Many species are curiously local in their distribution, even though they are, in total, widely distributed.

All species so far investigated in culture are low-temperature forms, having their optimum growth-temperature below 30°C. and their maximum slightly above that point. This peculiarity is reflected in species-distribution: most species occurring in temperate regions, and, of the tropical species, many occurring at higher altitudes.

Forty-seven species are known from America north of Mexico. The present paper brings the species known to occur in Kansas to ten.

The following record of distribution of species of *Taphrina* in Kansas is based on specimens seen[1] by the writers or collected by them (or one of them). Specimens reported in the lateratutre have all been examined and the identifications confirmed.

1. *Taphrina caerulescens* (Mont.) Desm.
   a. On *Quercus macrocarpa* Michx. Collected at Hays, June 6, 1930 by E. Bartholomew (N. A. F. 10957); Baxter Springs, July 31, 1948, R. L. McGregor; Lawrence, May 14, 1946, A. J. Mix; Pittsburg, July 5, 1948, R. L. M.; 5 mi. n.e. of Ottawa, Franklin Co., May 20, 1949, R. L. M.
   b. On *Quercus marilandica* Muench. Baldwin, June, 1933, and several times since, A. J. M.; Baxter Springs, July 31, 1948, R. L. M.; Kent, Leavenworth Co., May 29, 1948, R. L. M.
   c. On *Quercus maxima* Ashe, 5 mi. n.e. of Ottawa, Franklin Co., May 20, 1949, R. L. M.
   d. On *Quercus prinoides* L. Vinland, Douglas County, May 14, 1946, A. J. M. This is a new host for *T. caerulescens.* The host was erroneously identified (Mix, 1946) as *Quercus muhlenbergii*

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[1] Thanks are due to Prof. L. E. Melchers for allowing examination of specimens in the Herbarium of Kansas State College.

Engelm. The fungus is not known on *Q. muhlenbergii.*

e. On *Quercus velutina* Lam., Galena, July 3, 1948, R. L. M.; Crawford Co., 8 mi. north of Pittsburg, July 5, 1948, R. L. M.; Uniontown, Bourbon Co., July 5, 1948, R. L. M.; 5 mi. n.e. of Ottawa, Franklin Co., May 20, 1949, R. L. M.

2. *Taphrina communis* (Sadeb.) Gies.

a. On *Prunus americana* Marsh. Abilene, May 22, 1926, H. W. King; Baldwin May, 1926, and many times since, A. J. M.; Belpre, June 9, 1924, R. P. White; Bluff City, Harper Co., May 24, 1894, G. W. Wilson; Jennings, Decatur Co., Summer, 1892, A. S. Hitchcock; Lawrence, May 23, 1939, R. Sailer; Manhattan, May 25, 1882, W. A. Kellerman; Natoma, Osborne Co., June 10, 1891, Benjamin Brown; Rockport, Rooks Co., June 20, 1889, 30, 1891, June 1894, E. Bartholomew (N. A. F. 298); Rooks Co., May 24, 1895, E. Bartholomew, (Econ. F. 465a), May 24, 1901, id., (F. Columb. 1533); Stockton, June 1, 1903, E. Bartholomew (F. Columb. 1927).

b. On *Prunus angustifolia* Marsh. Lawrence, June, 1923, and many times since, A. J. M.; Lecompton, May 15, 1947, R. L. M.; Spohr's Bottom, June 23, 1883, Carleton and McKeen.

3. *T. cystopteridis* Mix, on *Cystoperis fragilis* (L.) Bernh., Neodesha, June 1936, W. H. Horr; June 1937, June 1938, A. J. M. This fungus is known elsewhere only from Daviess County, Indiana, and from Brodhead, Wisconsin.

4. *Taphrina deformans* (Berk,) Tul. On cultivated peach. Widespread.

5. *Taphrina farlowii* Sadeb., on *Prunus serotina* Ehrh., Vinland, Douglas Co., May 1947, A. J. M.

6. *Taphrina flavorubra* Ray.

a. On *Prunus besseyi* Bailey. Stockton, May 20, 1889, E. Bartholomew (N. A. F. 288).

b. On *Prunus pumila* L. Rockport, Rooks Co., May 20, 1889, E. Bartholomew; ibid., May 1895, id. (N. A. F. 3338). Rooks County, 1893, E. Bartholomew (F. Columb. 924).

7. *Taphrina purpurascens Robins.* on *Rhus copallina* L. Baxter Springs, July 4, 1948, R. L. M.; Morehead, Neosho Co., June 30, 1947, R. L. M.; Neodesha, Wilson Co., July 1, 1947, R. L. M.; Yates Center, Woodson Co., July 1, 1947, R. L. M. This fungus is known also from Arkansas, Connecticut (on *R. glabra* and *R. typhina),* Massachusetts, New Jersey, and Virginia.

8. *Taphrina sacchari* Jenkins, on *Acer saccharum* Marsh. Independence, May 11, 1944, G. W. Stafford; Fort Scott, July 5, 1948, R. L. M.

Known elsewhere from Arkansas, Maine, and Pennsylvania, and on *A. nigrum* Michx. from Ohio.

9. *Taphrina ulmi* (Fkl.) Johans.
   a. On *Ulmus fulva* Michx. Baldwin, June 15, 1947, A. J. M.
   b. On *Ulmus thomasii* Sarg. Baxter Springs, July 31, 1948, R. L. M. *Ulmus thomasii* is a new host for this fungus.
10. *Taphrina virginica* Sadeb. On *Ostrya virginica* Willd. Baldwin woods near Vinland, Douglas Co., May 15, 1947, A. J. M.; ibid. May 13, 1949, id., Lecompton, May 15, 1947, R. L. M.; 4 mi. n. of Bonner Springs, Wyandotte Co., May 20, 1949, id. This fungus seems to be rather rare. It is known from Massachusetts, New Hampshire, Vermont, Wisconsin, and Ontario. In the Kansas localities it was only found on four trees, although the stands of *Ostrya* ran into the hundreds.

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An Anatomical Study of Melampodium leucanthum, a Drouth Resistant Plant

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One of the conspicuous drouth resistant plants found in the high plains and prairies of the southwestern fourth of Kansas and southwestern United States is *Melampodium leucanthum* T. and G. It is an herbaceous perennial, with many slender stems rising from 6 to 12 inches from the woody crown, above a strong taproot.

The remarkable drouth resistant properties of this plant made it seem worth while to investigate the anatomical structure.[1]

Anatomical Description

Stem

The structure is typically that of a nonsucculent herbaceous plant. The center of the stem is occupied by pith made up of relatively thick walled parenchyma cells, with a few small intercellular spaces. The stele is a dissected ectophloic siphonostele with collateral type bundles. (Plate I. Fig. A.) The primary vascular system consists normally of ten radially distinct bundles.

A large proportion of the xylem is made up of wood fibers, from 0.50 mm to 0.15 mm in length (average length, 0.25 mm). (Plate I. Fig. B, C, D.) Tracheids are rare, and vessels are few in number. The vessel segments are of the porous type having an average length of 0.25 mm. (Plate I. Fig. E, F, G, H.) The maximum length of these segments being 0.30 mm, and the minimum being 0.12 mm. The pitting observed in the vessel segments is of the simple type. Wood parenchyma is scattered throughout the primary xylem.

The primary phloem is very small in amount and consists of sieve tubes, companion cells, and phloem parenchyma.

The pericycle consists of a group of sclerenchyma fibers adjacent to the phloem, and forming a caplike structure over the vascular bundle. Parenchyma cells are found between the sclerenchyma caps of the pericycle.

The cortex is composed at its periphery of from 2 to 3 rows of tubular collenchyma cells. The remainder of the cortical region consists of relatively thick walled parenchyma. The intercellular spaces in the

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[1] The authors wish to express appreciation to Mr. R. L. McGregor for his advice and assistance throughout this work. The material studied was collected in June of 1936, between Coldwater and Dodge City by W. C. Stevens. It was preserved in F. A. A. Additional material was furnished by W. H. Horr.

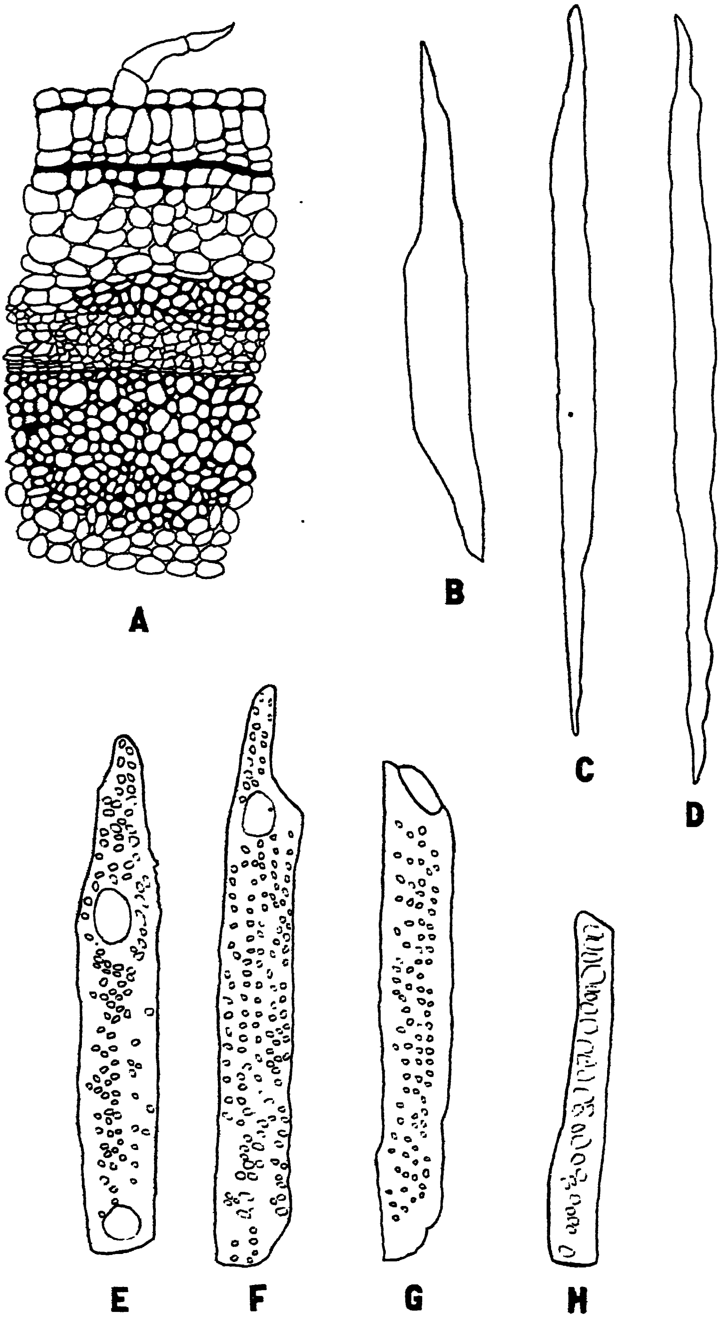

PLATE I. Fig. A. Stem cross section showing secondary growth. X 166.6. Fig. B, C, D. Wood fibers. X 387. Fig E, F, G, H. Vessel elements. X 387.

parenchyma of the cortex are few and rather small. An endodermis was not obesrved.

The epidermis is uniseriate and is covered by a very thin layer of cutin. Appressed trichomes, consisting of from three to five cells are abundant.

The cambium becomes active early to form a limited amount of secondary xylem and phloem. The cambium functions until approximately the time of flowering. Secondary xylem and phloem form a continuous cylinder, giving rise (in the mature body) to a continuous ectophloic siphonostele. Further secondary growth is exhibited early by the differentiation of a cork cambium in the first layer of collenchyma cells immediately beneath the epidermis. This forms from 2 to 4 rows of cork cells leaving the epidermis entirely intact.

Leaf

The upper leaves are linear and the lower are oblanceolate. They are sessile, from 3 to 5 cm long, entire or sinuately lobed. The epidermal surfaces of the leaf are covered by multicellular hairs. These are similar to those found on the stem but are not so appressed. (Plate II. Fig. A, B.) The upper and lower epidermis exhibit the jig-saw pattern typical of the dicotyledons. (Plate II. Fig. C, D.). Such an arrangement is due to the undulate outline of radial walls. The cuticle on the leaf, as on the stem, is very thin. Stomata are found on both surfaces, the average number on the upper surface being 195 per sq. mm, and on the lower 250 per sq. mm. The superficial view of the leaf reveals the midvein to be conspicious on both surfaces. It is the only large vein present. The rest of the veins are obscure, netted, and approaching an open type of venation. Vein islets average 0.32 mm across. (Plate II. Fig. E.) All veins, including the midvein, lack an appreciable amount of sclerenchyma. In a cross section parenchyma cells with rather large intercellular spaces are seen to make up the greater part of the leaf. (Plate II, Fig. F. G.) A hypodermal layer of from 1 to 2 rows of collenchyma cells is present. The support given by these veins is due therefore to the turgidity of the cells rather than to mechanical tissues. Vascular tissue of the leaf corresponds favorably to that of the stem.

The mesophyll is that of a typical bifacial leaf. The palisade mesophyll exists as one definite layer, but it shows some tendency toward two layers in places. It comprises about one-third of the area of the mesophyll. The spongy mesophyll is relatively compact, with isodiametric cells.

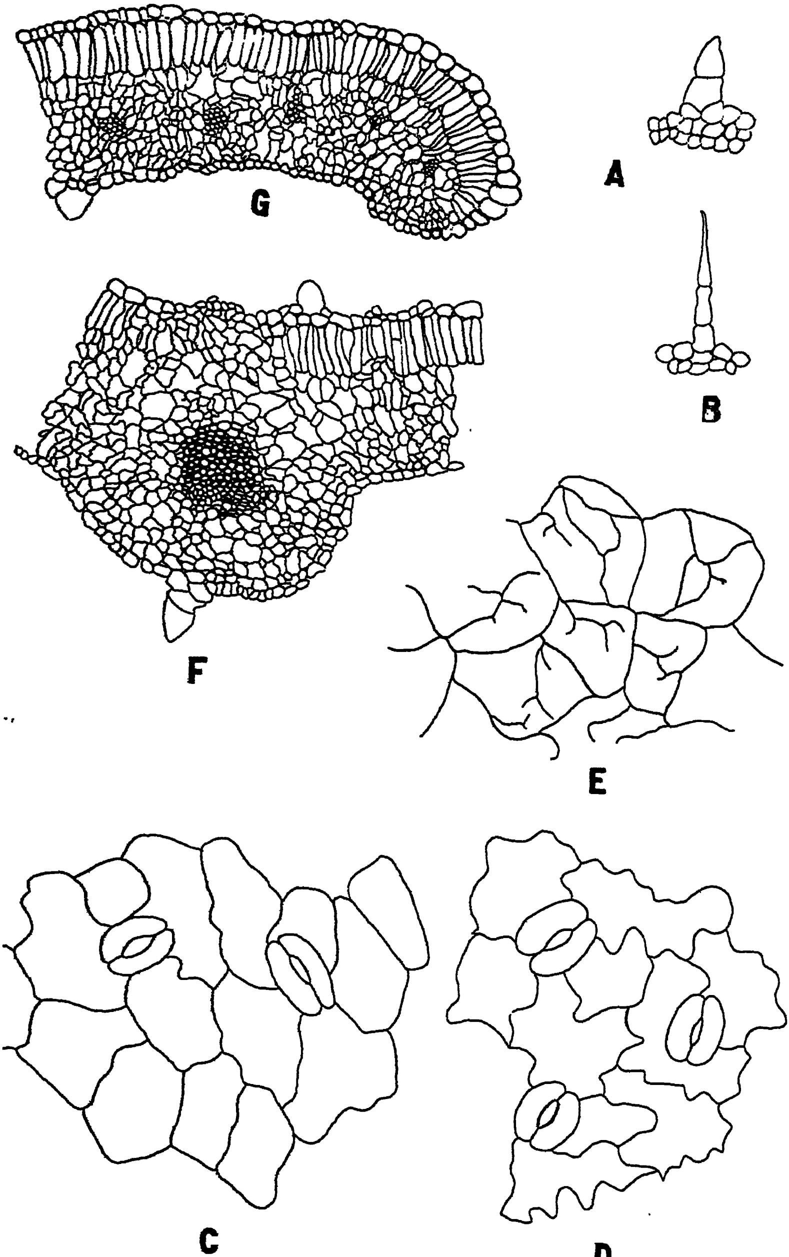

PLATE II. Fig. A, B. Clothing hairs, leaf. X 67. Fig. C. Upper epidermis. X 395. Fig. D. Lower epidermis. X 395. Fig. E. Leaf ventation. X 395. Fig. F. Leaf cross section at midrib. X 80. Fig. G. Leaf cross section. X 80.

Root

The perennial root system was observed to be like that of dicotyledons in general.

Summary

The stem organization is typically that of an ectophloic siphonostele.

Mesophyll of the leaf is that of a typical bifacial leaf.

Sclerenchyma fibers are present in the stem and leaf organization.

The cuticle on the stem and leaf is a very thin layer.

Parenchyma tissues throughout the stem exhibit thicker walls than commonly observed in dicotyledons.

No unusual anatomical structures were observed that would aid in explaining the drouth resistance of this plant.

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Cover Restoration in Kansas

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Our particular concern, as indicated by the title of this paper, is cover restoration and habitat improvement. Cover restoration means what the two words imply, that is, restoring cover and feed to those areas which are, to all practical purposes, devoid of any wildlife attributes. Habitat improvement involves restoring to the existing vegetation the plant, or plants necessary to provide the optimum in wildlife environment.

We of the Kansas Forestry, Fish and Game Commission, being ever more aware of the progressive disappearance of wildlife cover from the land, through more and more intensive agricultural practices, and the alarming rate at which the old osage orange hedges are being removed, have instigated a program of this nature. In establishing this new program, we have taken into consideration the fact that the average landowner's interest in wildlife is strictly secondary. If his acres can be managed so as to produce a sizable return and, at the same time, encourage and abet wildlife,—well and good; if not, then wildlife must suffer. With these thoughts in mind we endeavored to select those species of plants which offer the maximum benefits to the landowner and to wildlife.

At present, multiflora rose seems to be the most promising plant, offering almost ideal escape cover for wildlife as well as a reserve winter food supply and affording the landowner both economic and esthetic value in the form of a living stock-proof barrier, which is quite ornamental as well. This plant is apparently tolerant of soils and weather conditions, with records of persistence on the poorer soils and the colder climates of our country. It also seems to be able to persist in areas of relatively low precipitation. At maturity (three to six years, depending upon conditions), multiflora rose attains a growth of approximately six to eight feet in width and six to eight feet in height. It blossoms once a year, usually in May or June, and fruits in the late fall. These fruits are small, dark-red, apple-shapped berries which adhere to the parent plant until late winter, offering a reserve winter food supply for our wildlife. Multiflora rose has many favorable characteristics, when used as a living fence that osage orange does not possess. With the farming practices now in use, multiflora rose will not spread; it does not retard adjacent plant growth; it occupies a relatively small amount of crop land, very little more than is necessary to maintain a good woven-wire fence; there is practically no maintenance necessary since it does not

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require trimming or the cleaning out of dead wood; and its height is not great enough to offer a problem in shading adjacent areas.

Multiflora rose has enjoyed a rather interesting and encouraging growth experience in some of the midwestern states during the past few years. However, until this spring there had been no plantations of any consequence established in Kansas. Since the supply of multiflora rose seedlings was very limited during the but recently-passed planting season, we felt fortunate in being able to obtain two hundred thousand plants. From this number of seedlings we established approximately one hundred seventy plantations, on all the general soil types found in Kansas. It is from these one hundred seventy established areas that we hope to obtain the information and data concerning growth rate, range, drought resistance, soils tolerance and wildlife cover.

While we feel that multiflora rose is the most promising plant we have at hand, we are cognizant of the old adage regarding the transportation of eggs: never carry them all in one basket. In addition to this is the fact that escape cover, which is provided by multiflora rose, is not always the factor needed in improving habitat. For example, a given area may already have a sufficient amount of the cover qualities of multiflora rose but may be woefully lacking in nesting and roosting areas; another area may possess all the necessary requisites except winter feed, and so on. Therefore, in an effort to discover a plant, or plants, which will persist in our state and which will offer to wildlife the above requirements, we have established several limited plantations. The plants with which we are concerned in these experimental areas are: sericea lespedeza, Korean lespedeza, bicolor lespedeza, sand lovegrass, African lovegrass, Russian olive and red cedar.

We realize, only too well, that each of the above plants has its limitations, especially in regard to range and utility. But, from these experimental plantings we hope to determine where they will best fit into the existing conditions.

After our experience this past fall and spring in attempting to procure multiflora rose seedlings, we decided to establish a nursery of our own to increase the supply of these plants until such time as other sources are able to do so. The nursery is located on the Kingman County State Park, some twenty-three miles east of Pratt. On this area we fall-sowed some six million multiflora rose seeds. This spring, we have sowed some two million multiflora rose seeds, fifty thousand bicolor lespedeza seed and a very limited amount of Russian olive. From these seedlings we hope to obtain something near one million multiflora

rose seedlings for distribution to Kansas landowners in 1950 and enough seedlings of the other species for our own experimental areas.

It is the intention and aim of the Kansas Forestry, Fish and Game Commission, through the use of these plants and any others which may in the future warrant further experimentation, to initiate and establish a simple, practical and usable cover restoration and habitat improvement program that will be a great benefit to all concerned.

Kansas Phytopathological Notes: 1948[1]

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Phytopathological notes are published in order to record with reasonable regularity the occurrence, distribution and severity of disease of economic crops in Kansas. Too often in the past there has been no published record by which the appearance and importance of crop diseases in the state could be traced. These notes are prepared to provide such a record as well as to record any new diseases or unusual developments of older ones.

Weather as Related to Plant Diseases in 1948

As usual, the weather played a most important part in the development of crops and diseases in Kansas in 1948. Alternating periods of drouth and heavy rainfall and of high and low temperatures had profound effects on both crops and diseases. These periods are shown in table 1.

The effect of weather conditions on the development of crops and diseases is well illustrated by the 1948 wheat crop. The period from July through November 1947 was one of deficient rainfall in all parts of the state. Temperatures were considerably above normal in August, September, and October. As a consequence it was impossible to prepare seedbeds for wheat in some localities until very late, and most seedbeds were very dry and cloddy. These conditions greatly delayed planting, which in some communities was not finished until late December. Late sowing coupled with poor seedbeds delayed germination and resulted in uneven stands. In the western part of the state some wheat did not emerge until February or March. Therefore there was little top growth in most of the fields in the fall of 1947, and in many localities there was no fall emergence. As a result there was almost no development of leaf or stem rust on wheat in the fall of 1947 and therefore little or no overwintering of rust. Much the same conditions prevailed in Oklahoma, which assured that any large source of rust inoculum would be far from Kansas in the spring of 1948, which in turn meant that spring rust infections were likely to be late in inception and generally light in severity.

During the winter and early spring the condition of the 1948 Kansas wheat crop appeared to be very poor. Late emergence of wheat and the dry period during April and May resulted in thin stands and lack of tillering. The warm dry weather of those two months caused early heading,

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with the plants apparently lacking in leafiness and having unusually short straw. These conditions were unfavorable for the development of rusts on wheat in Kansas until very late in the season. A large percentage of the wheat acreage therefore was practically rust-free throughout the season.

Table 1.—Kansas Meteorological data for the crop season 1947-48[1]

	Precipitation in inches					Temp. in degrees F.	
	Deviation from Mean			State		State	
	East third	Central third	West third	Mean	Deviation	Mean	Deviation
1947							
July	— 1.48	— 1.29	— .79	1.91	— 1.19	77.6	— 1.6
Aug.	— 1.60	— 1.65	— .68	1.84	— 1.31	83.2	+ 5.2
Sept.	— .76	— 2.28	— 1.27	1.40	— 1.43	74.0	+ 4.2
Oct.	— .54	— .91	— .61	1.29	— .69	65.8	+ 8.3
Nov.	— .51	— .15	+ .35	1.17	— .10	39.5	— 3.7
Dec.	+ 1.42	+ 1.50	+ .62	2.08	+ 1.17	34.3	+ 1.2
1948							
Jan.	— .26	— .05	— .02	0.59	— .11	27.9	— 2.2
Feb.	— .05	+ 1.39	+ .56	1.62	+ .63	30.9	— 2.4
Mar.	+ 1.68	+ .90	+ 1.10	2.73	+ 1.23	36.9	— 6.5
Apr.	— 1.04	— 1.39	— 1.79	1.28	— 1.41	61.1	+ 6.2
May	— 1.51	— 1.57	— .24	2.69	— 1.11	64.7	+ 0.9
June	+ 2.42	+ 3.13	+ 1.95	6.75	+ 2.49	73.6	— 0.2
July	+ 4.95	+ 3.48	+ .39	6.09	+ 2.94	77.8	— 1.3
Aug.	— 1.18	— .37	+ 1.37	3.04	— .11	77.3	— 0.7
Sept.	— 1.86	— 1.30	— .96	1.42	— 1.41	72.0	+ 2.2
Oct.	— .96	— 1.03	— .93	.96	— 1.02	56.9	— 0.6
Nov.	+ .36	+ 1.33	+ .79	2.12	+ .84	42.1	— 1.1
Dec.	— .62	— .43	— .33	.42	— .48	34.4	+ 1.2

Although the fall, winter, and early spring were unfavorable for the development of cereal crops, abundant rains and below normal temperatures in June and July were very favorable and most cereals made an astonishing recovery. The prolonged growing season combined with freedom from diseases resulted in unexpectedly high yields in the winter wheat crop that had appeared disappointing in April. The final yield was 231,368,000 bushels, although part of the grain was damaged by heavy rains in June and July which prevented harvesting at the proper time and by lack of storage facilities for properly drying wet grain. An unusual feature of the 1948 wheat crop in Kansas was that some wheat was harvested in every month from June to December, inclusive. The extremely late harvestings were of fields that were too wet or too weedy for harvesting at the proper time. Grain from such fields was naturally of poor quality and fit only for feed, although the yield was surprisingly good.

Observations on Cereal Rusts and Smuts

The year 1948 definitely was not a rust year in Kansas. A large percentage of the acreage of both wheat and oats was virtually rust-free until maturity—a condition that seldom occurs. Several factors unfavorable to rust development operated in the proper sequence to produce the condi-

[1] Data compiled from monthly reports by S. D. Flora, in Climatological Data, Kansas Section, U. S. Department of Commerce, Weather Bureau, 61, Nos. 7-12, 1947 and 62, Nos. 1-12, 1948.

tion. These were: (1) absence of fall infections of the various rusts and therefore (2) no overwintering; (3) small amount of inoculum during the spring in states south of Kansas; (4) long period of dry, hot weather in April and May; (5) early maturity of the wheat crop in southern counties where heavy rust infections usually start.

Leaf rust of wheat (*Puccinia rubigo-vera tritici*) was the lightest ever observed in Kansas. As late as June 18 it was extremely difficult to find even a few isolated uredia in many fields in the western third of the state, and infections were seldom above 5 percent in the central and eastern sections. No fields were observed or reported in which there was an appreciable loss from leaf rust.

Stem rust of wheat (*P. graminis tritici*) also was very light in 1948, although there were a few small areas where stem rust was heavy and did some damage. In a small area in the extreme southeastern corner of the state, stem rust was very heavy and caused considerable shriveling of the grain. A fairly heavy infection of stem rust developed in a few north central counties, particularly Republic and Cloud, about the middle of June but the grain produced in that area showed no stem rust damage and yields were good. One of the surprising features of the infections of stem rust in 1948 was their widespread distribution and their occurrence principally on the leaves. In almost every field occasional uredia of stem rust could be found on the leaves, even in those where it was impossible to find leaf rust.

Crown rust of oats (*P. coronata avenae*) was very light until late in June when it developed heavily in some fields in the eastern part of the state. The large acreage of resistant varieties probably was partly responsible for delayed infection. Most of the heavily infected fields were Clinton, which usually has been highly resistant to crown rust in Kansas. This indicates that physiologic race 45 or some similar race able to infect Clinton is increasing in the state.

Stem rust of oats (*P. graminis avenae*) was unusually light in 1948. This probably was due partly to the late inception of infection and partly to the large acreage of resistant varieties such as Clinton, Osage, Neosho, Nemaha, and Cherokee.

Stem rust of barley (*P. graminis*) was present in nearly all fields late in the season but was not observed in damaging amounts anywhere. It behaved much like the stem rust of wheat in that much of the infection was in the form of isolated pustules on leaves.

Although rusts of cereal crops had little or no effect on yields in Kansas in 1948, the following estimate of their importance is presented as a matter of record:

Leaf rust of wheat (*Puccinia rubigo-vera tritici*) present, no loss
Stem rust of wheat (*P. graminis tritici*) trace loss
Crown rust of oats (*P. coronata avenae*) trace loss
Stem rust of oats (*P. graminis avenae*) trace loss
Leaf rust of barley (*P. hordei*) present, no loss
Stem rust of barley (*P. graminis*) present, no loss.

Loose smut (*Ustilago tritici*) of wheat caused an average loss of 0.5 percent in 1948. The maximum infection observed was 12 percent in a field of Clarkan wheat in east central Kansas. Environmental conditions were favorable for loose smut infection during the blossom period in the latter half of May, 1947; however, the inoculum available for infection was relatively low, since rainfall had been deficient the previous blossom period. The average loss was also low because 35 percent of the acreage of the state was planted to the highly resistant variety Pawnee. No loose smut was observed in pure fields of Pawnee and Kawvale.

Bunt (*Tilletia foetida*) of wheat caused an average loss of 0.1 percent in 1948. A field of Red Chief was observed in central Kansas with 75 percent of the heads infected with bunt. The highest loss observed in other varieties was 28 percent in a field of Tenmarq in central Kansas. The fetid odor of trimethylamine from the bunt in this field was detected while traveling by automobile at 55 miles per hour along the highway adjacent to the field. Detection of bunt in fields of wheat while traveling on the highways was common 20 to 30 years ago when high losses from bunt occurred every year. Average losses from bunt have been very low during the last few years, due to an increase in acreage of the resistant varieties Comanche and Pawnee and to a statewide practice of seed treatment of susceptible varieties.

Smut (*Ustilago avenae* and *U. kolleri*) of oats caused an estimated loss of 0.6 percent in 1948. This was the lowest annual loss from smut during the last two decades. This low loss in smut was due principally to an increase in acreage of resistant and moderately resistant varieties of oats. The maximum infections observed were 52 percent in a field of Kanota in central Kansas, 5 percent in a field of Fulton in north central Kansas, and 5 percent in a field of Clinton in north central Kansas. The average loss in fields of the susceptible variety, Kanota, was 5.5 percent while that of the moderately resistant varieties Fulton was 0.5 percent and of Clinton was 0.3 percent. Fields of Osage, Neosho, Boone, Tama, Cedar, Vicland, Cherokee and Nemaha were relatively free from smut.

Brown loose smut (*Ustilago nuda*) of barley again was the most destructive disease of this crop, causing an average loss of 7 percent in 1948. This was the sixth consecutive year with annual losses of 5 percent or

more. Fields of barley with losses of 10 to 30 percent were common. The maximum infections observed were 46 percent in a field of Beecher spring barley in northwest Kansas and 29 percent in a field of Reno winter barley in south central Kansas. The average losses for black loose smut (*U. nigra*) and covered smut (*U. hordei*) were 2 and 1 percent, respectively. Smut has been the limiting factor in satisfactory barley production in Kansas.

Observations on Other Cereal and Forage Crop Diseases

The wheat root rots were unusually light this year. Take-all (*Ophiobolus graminis*) which may cause a very high loss in individual fields during an average year was difficult to find in any portion of Kansas. The dry condition during the fall and spring perhaps accounted for this. Dry land crown rot was observed in very few fields. This is a disease of early planted wheat. Wheat planted in the fall of 1948 did not emerge until late, due to the dry soil.

Septoria leaf blotch (*Septoria tritici*) was prevalent over the entire state but in rather a mild epiphytotic. Losses from this disease are difficult to estimate accurately.

The new wheat leaf disease, formerly reported under the name "yellow spot,"[3] was found in many parts of the state. It was very mild except in Riley county where even the flag leaves in some fields were heavily infected. Field observations have shown that Pawnee wheat is a very susceptible variety.

Wheat mosaic, a virus disease, is usually so slight in Kansas that it escapes attention. During 1948 it was widespread and in some areas caused considerable loss. The loss was the greatest in the northwestern part of the state. Fields were observed in Norton and Decatur counties where the losses ran as high as 75 percent. It was especially severe on early emerged wheat. In Norton and Decatur counties there was enough moisture for early germination. The only other year that mosaic was severe in Kansas was 1930 and this was in the same general region of the state.

Light infection of ergot (*Claviceps purpurea*) occurred in wheat x *Agropyron* spp. hybrids at the Agronomy farm. Infection developed principally in hybrid selections which were partly or completely self sterile. In these selections the lemma and palea remain open for relatively long periods, in some instances for a week or more.

Victoria blight (*Helminthosporium victoriae*) of oats caused high losses again in 1948. The estimated loss in susceptible varieties in northeastern Kansas was 20 percent, in southeastern Kansas 30 percent, in central Kansas 8 percent, and in western Kansas 0.1 percent. Seed treatment

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[3] Kansas Mycological Notes: 1945. Trans. Kans. Acad. Sci. 49:175-183. 1946.

with New Improved Ceresan at the rate of ½ oz. per bushel was effective in increasing the yield of susceptible varieties of oats by 7 bushels per acre. Crop rotation was also effective in increasing the yield of susceptible varieties of oats. Where crop rotation was not followed losses from Victoria blight were very high, especially in southeastern Kansas, and many fields were not even harvested.

Clinton, Cherokee, and Nemaha were recommended for distribution in Kansas in 1948. These varieties are highly resistant to Victoria blight and resistant to the races of rust and smut now prevalent in Kansas. All of these varieties stood up very well in comparison to other commercial varieties grown in the state.

The bacterial blights of sorghum, bacterial stripe (*Pseudomonas andropogoni*), bacterial streak (*Xanthomonas holcicola*) and Holcus spot (*Pseudomonas syringae*), were more prevalent and severe on sorghum than they have been for many years. During the two-month period from the middle of June to the middle of August, it rained a trace or more on more than 30 days at most of the weather stations in Kansas. This extended period of rainfall was very favorable for bacterial infection of sorghum. The hot dry weather the latter part of August and during September and October was favorable for charcoal rot (*Sclerotium bataticola*) of corn and sorghum.

Anthracnose (*Colletotrichum graminicolum*) was destructive on broomcorn in southwestern Kansas where the crop is grown. It caused breaking over and weakness of plants and development of poor brush. This is the first time this disease definitely has been reported on this crop in Kansas. Anthracnose has been severe on broomcorn in Illinois for several years (1941, '42, '48), being first reported from that state. Since seed importations have been made into Kansas from Illinois, it seems possible that this may have been a source of introducing anthracnose into the Kansas crop.

Notes on Fruit, Vegetable and Tree Diseases

Brown rot (*Sclerotinia fructicola*) of stone fruits was more severe on peaches and other stone fruits than has been noted in Kansas for many years. Undoubtedly the abundance of rainfall in June and July was a factor in making it favorable for an epidemic. Approximately 30 percent of the peach crop was lost from this disease. Growers apparently were not prepared for such an outbreak and control measures were not generally practiced.

Irish potato diseases in general were less conspicuous in 1948 and caused less damage than for a number of years. Rhizoctonia has been less in Kansas than the last two or three seasons. This is partially explained by

the fact that less heavily infected seed is coming into Kansas than in the past; seed is being dug earlier in the northern states and the sclerotia of the organism are not so abundant. Seed tratment is not practiced any more than it has been in Kansas, so this cannot be the explanation of the absence of Rhizoctonia. Blackleg (*Erwinia atroseptica*), a bacterial disease, was very little in evidence. Potato scab (*Streptomyces scabies*) was not a problem of importance.

One of the most striking examples of the absence of diseases in a crop was in the case of sweetpotatoes. For many years this crop has had large losses from stem rot (*Fusarium axysporum batatatis*), black rot (*Ceratostomella fimbriata*), and pox (*Streptomyces ipomoea*). The latter has been increasing steadily in Kansas for the last eight years. It is now regarded as the most serious disease of sweetpotatoes in Kansas. In 1948 many fields were examined and all 3 of these diseases were conspicuous by their absence. This is unexplainable. One had difficulty in locating enough specimens for class use.

Bacterial wilt (*Erwinia tracheiphilia*) of muskmelons was severe in Grant County where the crop is one of considerable importance under irrigation. In 1947 only 2 percent infected plants were observed. In 1948 one-third of the entire crop of muskmelons in this county was lost from this disease. Many hundred acres are grown in Kansas and unless something is done to prevent spread of bacterial wilt, this crop will not be profitable.

Elm phloem necrosis, a virus disease of the American elm was first reported in Kansas in 1946. It has been found in several cities of eastern Kansas. Up to 1948 its spread in such places as Manhattan has not been so rapid as one might have expected. Only 7 trees definitely have been diagnosed as having phloem necrosis and these were promptly removed. However, several other American elms died during this period from causes undetermined. A definite spray program to control the insect vector, a leaf hopper, has been in operation in Manhattan for 3 years with the hopes that the disease may be held in check. The work is not far enough advanced to predict what the outcome will be.

Elm mosaic, another virus disease, has been common for a number of years in Kansas. It has been responsible for the gradual decline of a large number of American elms. Trees, although infected, continue to live for long periods although they become weaker and finally die.

Studies on Newcastle Disease

II. The Distribution of Newcastle Disease Virus Antibodies in the Tissues of Recovered Chickens*

L. D. BUSHNELL and L. E. ERWIN

Introduction

Following recovery from an attack of Newcastle disease the bird is highly immune to the disease. Serum of such birds contains considerable amounts of free antibody, which can be demonstrated by means of a hem-agglutination-inhibition test. In studying the development of immunity to Newcastle disease it is of interesest to determine, if possible, whether any tissue antibodies independent of those circulating in the blood stream are developed. In this connection it also seemed desirable to compare adsorption capacity of normal chicken tissues and the neutralizing action of antibodies which are present in the tissue extracts.

Methods

Chickens of about four to six weeks of age which had recently survived an attack of Newcasle disease in an outbreak in which the mortality was over 80 percent, were used in these experiments. All the birds examined had high titer sera and all still showed symptoms of encephalitis, although they were eating well and otherwise appeared to be normal.

The birds were killed by decapitation with a pair of heavy shears. The skin was removed and the following tissues obtained: thigh muscle, breast muscle, liver, kidney, lungs, brain, spleen, bone marrow, peripheral nerves (ischiadic), and blood serum. In each instance the tissues from two birds were freed of excessive moisture, pooled and weighed as soon as possible. The tissues were then ground in a mortar with ten times their weight of physiological saline of pH 7.2 and a small amount of washed quartz sand. This suspension was centrifuged for 15 minutes at 3000 r.p.m. to sediment all cells, and the supernatant fluid was removed and considered as a 10 percent extract of the tissue. The 1-10 diluted extracts contained so much antibody that agglutination was inhibited in all tubes, hence such further dilution was made as found necessary. Most tests were run with 1-10 dilutions of the tissue extracts.

In table I is presented the results of seven such experiments. The results included are quite irregular since there was marked variation with different tissues and with different birds.

Some of the tissue extracts, after dilution, did not exhibit any evidence of the presence of blood. However, those from the lungs, spleen, liver, kidney, and bone marrow were tinged with hemoglobin. In order

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to determine how much influence the incorporated blood would exert on the reaction, an estimate was made of the hemoglobin by comparing the color in the extract with that of hemolyzed chicken cells, mixed with an extract of breast muscle to equalize turbidity. The lungs and marrow exhibited about the same hemoglobin as a 1.0 percent red blood cell suspension, while the hemoglobin content of the spleen, liver, and kidney extracts was about one-fourth as high. Titrations were then made using the amounts of serum indicated above and the results included in the table. Apparently the influence of the serum incorporated in the various tissues was adequate to account for most of the difference observed among the various tissue extracts. The slight inhibiting effects of most extracts were of about the same order as those observed with known negative serum.

Table I. Distribution of antibodies in the tissues of chickens which had recovered from Newcastle disease.

	Dilutions									
Tissue (1-100)	10	20	40	80	160	320	640	1280	2560	Control
Thigh	7	7	7	7	7	7	1	0	0	0
Breast	7	7	7	7	7	7	1	1	0	0
Liver	7	5	5	5	3	1	1	0	0	0
Kidney	7	5	5	3	0	0	0	0	0	0
Lung	5	5	1	0	0	0	0	0	0	0
Brain	7	7	7	7	7	2	1	1	0	0
Spleen	7	5	5	3	0	0	0	0	0	0
Marrow	7	7	5	2	1	0	0	0	0	0
Nerves	7	7	7	7	7	7	5	0	0	0
Serum	7	7	5	3	0	0	0	0	0	0
Known Negative Serum 1-5	7	7	7	7	7	7	5	3	0	0
Known Positive Serum 1-5	3	0	0	0	0	0	0	0	0	0
Known Positive Serum 1-100	7	7	7	7	0	0	0	0	0	0
Known Positive Serum 1-200	7	7	7	7	7	0	0	0	0	0
Known Positive Serum 1-400	7	7	7	7	7	7	7	0	0	0
Virus	7	7	7	7	7	7	7	7	0	0

The figures listed above indicate the number of samples which gave complete agglutination of 0.5 percent chicken erythrocytes. When the figure 7 is used this indicates that there was 4-plus agglutination in all samples. If a smaller figure is given this indicates that some of the tests did not give a 4-plus reaction. However, those results have been included in order to give a more complete picture of the results obtained by such experiments.

Discussion

Certain early investigators were inclined to regard the process of immunity in virus disease as differing from those of bacterial infections. As far as Newcastle disease is concerned the resistance is apparently due to neutralizing substance produced in large amounts by infected tissue cells and accumulated in the blood serum. It has not been proved that this is a virucidal substance, but there are some indications from work done in the laboratory that it is not. From a practical standpoint the action is enough to prevent the pathogenic effect of the virus.

Evidently the tissues most severely injured in this disease, the central nervous tissues, do not contain an appreciable amount of antibody. The lungs and spleen appear to lead in this respect.

From a review of the literature is is evident that antibodies formed by tissue cells usually pass rapidly into the blood, where they predominate in

a ratio of 10 to 20 times the concentrations found in the tissues. These figures appear to be about on a par with those found in Newcastle disease.

Conclusions

1. Most chickens which have recently recovered from Newcastle disease are highly immune to that infection.
2. The blood serum of birds recovering from Newcastle disease contains a large amount of neutralizing antibody.
3. With the exception of lung tissue the blood confined to the tissues accounts for most of the neutralizing action of the tissue extracts of the immune bird.
4. No tissue immunity aside from that due to circulating antibodies was demonstrated by these tests.

Studies on Newcastle Disease

III. The Distribution of Newcastle Disease Virus in the Tissues of Chicks Visibly Sick of the Disease*

L. D. BUSHNELL and L. E. ERWIN

Introduction

When chicks become infected with Newcastle disease the virus appears to grow rapidly and the bird develops a generalized infection with early symptoms of a respiratory involvement followed by symptoms indicating injury to the central nervous system. Beaudette[1] reviewed the literature on the distribution of the Newcastle disease virus in the body of diseased and dead birds as determined by the infectiousness of the tissues tested. According to most reports the saliva, liver, spleen, lung, intestinal content, and brain and cord have yielded virus. The blood is less constant in this respect. No report is given of the amount of free virus present as measured by the hemagglutination titration. In this report are given the measured amounts of virus which could be eluted from tissues of chickens in well developed stages of the disease as determined by this reaction.

Methods

Five series of tests were made. The tissues used consisted of two samples of pooled material each from two chicks at two weeks of age, and three composite samples of materials from four chicks each of about the same age, all spontaneously infected with Newcastle disease virus.

Visibly sick birds were destroyed, tissues removed, weighed immediately, rendered free of excessive moisture and ground in ten times their weight of buffered physiological salt solution of pH. 7.2. The extract was centrifuged at 3,000 r.p.m. for 10 minutes and the supernatan fluid titrated for virus by means of the hemagglutination test, using 0.5 percent chicken red blood cells. The usual two-fold dilutions were made and the tests incubated at room temperature (23°-25°C) for 45 and 60 minutes, after which readings were made. If the red cells were spread uniformly in the bottom of the tube, without a button of sedimented cells, it was recorded as a 4+ reaction. In Table I is listed the number of the tests which gave a 4+ reaction. A figure 5 indicates that all five of the composite samples gave this type of reaction. If a smaller figure is given it indicates that only that portion of the specimens gave such a result.

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Table I. Showing Distribution of Newcastle Disease Virus in Tissues of Various Chickens With Symptoms of the Acute Disease.

	Dilutions								
Tissues	10	20	40	80	160	320	640	1280	2560
Thigh Muscle	0	0	0	0	0	0	0	0	0
Breast Muscle	0	0	0	0	0	0	0	0	0
Liver	2	1	0	0	0	0	0	0	0
Kidney	1	1	1	0	0	0	0	0	0
Lung	2	2	0	0	0	0	0	0	0
Brain	0	0	0	0	0	0	0	0	0
Spleen	2	1	0	0	0	0	0	0	0
Marrow	0	0	0	0	0	0	0	0	0
Nerves	0	0	0	0	0	0	0	0	0
Trachea	4	3	1	0	0	0	0	0	0
Blood	0	0	0	0	0	0	0	0	0

The figures in the above table indicate the number of the five pooled samples which gave a 4+ reaction.

Results

It is not possible to state whether the recorded values indicate the amount of virus present in the different tissues, or whether they merely represent the amount of virus which was dissociated from the tissues by treatment. Only in the tracheal exudate was there evidence of very much free virus. According to the above data the brain and blood would be poor quantitative sources of the virus. This does not mean that these tissues are free of virus, but rather that the concentration of free virus is relatively low. Such tissues might serve as potent inocula since they contain the infectious material, as was recorded in the report by Beaudette.

Conclusion

The data here presented, obtained by an entirely different procedure, substantiate the findings of other investigators that the saliva and tracheal exudate are probably the most potent sources of the Newcastle virus. The lung and liver and spleen rank next in order, while the brain and whole blood appear to be less important sources.

Literature Cited

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The Combination of Dyes with Growing, Resting, and Killed Bacterial Cells

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Many aniline dyes are employed by the microscopist in staining cells for the single purpose of increasing the visiblity of cells and their various constituents. Other dyes are employed as a means of gaining information relative to the physico-chemical structure of the cell or even its physiologic activities. In this latter group are the so-called vital stains, which are presumed to enter and react with certain constituents of the cell while the cell is still living and carrying on at least some of its normal life activities. Some examples of this type of staining are the use of Janus green to demonstrate oxidase granules in leucocytes; the use of neutral red, brilliant cresyl blue, and others, in studying diffusion phenomena in algal and other plant cells; and the use of many of these vital dyes in animal physiology to study the passage of molecules through cell membranes and their accumulation in various tissue cells (Hober, 1945).

The chemical structure of the dyes used in vital staining is not markedly different from that of other types of dyes and stains. They may be basic dyes in which, upon ionization, the colored bearing portion of the dye is located in the cation, or they may be acid dyes in which the chromophore is located in the anionic fraction. The more widely employed dyes used in vital staining are relatively weak in their basic or acidic properties. That is, they do not tend to ionize to a marked degree. This low degree of ionization may be an important feature of their molecular makeup since Osterhaut (1925) has shown that many weak acids and bases penetrate cellular membranes only as the undissociated molecules. Experiments by Irwin (1927) on the alga *Nitella* with brilliant cresyl blues at various pH levels, have likewise indicated that the rate at which the dye enters and leaves the cell is proportional to the percentage of the dye in an undissociated state. Accumulation of vital dyes within the cytoplasmic or vacuolar materials in plant and animal cells in greater concentrations than exists in the surrounding medium has been explained in several different ways. Such an accumulation is apparently due either to a higher solubility of the dye in the lipoidal components of the cell or to a greater degree of dye adsorption by some protoplasmic fraction such, for example, as nucleoproteins. In

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a few instances greater amounts of such dyes have been found to enter cells during active metabolism and to leave the cells following the cessation of respiratory activity. This has been explained upon the assumption that phenolic and other by-products of metabolism accumulate in the vacuoles, with which the dye molecules combine as they penetrate the cell, thus making the accumulation of these dyes the result of a Donnan equilibrium type of phenomenon.

Current ideas relative to the structure of the bacterial cell do not include a vacuole comparable to that of the typical cells of higher plants. On the contrary, certain species of bacteria are described as containing specialized granules of various types, some of which, however, may be of a vacuolar nature (Dubos, 1945). After observing cells of *Staphylococcus aureus*, Dufrenoy (1931) concluded that the entire central portion of the cell, which stained with neutral red, was a large central vacuole. Later Pratt and Dufrenoy (1947) in discussing this type of phenomenon in *Staphylococcus aureus* state "the vacuolar accumulation of vital dyes against a concentration gradient in normally functioning aerobic organisms is a physiological process entailing expenditures of energy that is derived from respiration;—". These concepts do not agree with certain other theories concerning staining of the bacterial cells. Knaysi (1935) studied vital staining in bacteria and concluded that neutral red and other vital dyes do not stain normal living bacterial protoplasm, but combine readily with it only after the cell has received a certain amount of injury. The preceding observations regarding the reaction of dyes with the bacterial cell were based upon the observation of the stained cells under the microscope. McCalla (1940) has shown that the adsorptive capacities of the bacterial cells for dyes and other ions may be measured by physico-chemical means. The experimental work herein reported was undertaken in an effort to measure quantitatively the rate of bacterial adsorption of dyes during metabolic activity and to compare quantitatively the adsorption of vital dyes by living and dead bacteria.

Since neutral red has been widely used as a vital stain, preliminary studies were made to determine the concentrations of this dye which could be tolerated by some common types of bacteria. The culture medium used throughout all the experiments reported in this study was a modified nutrient broth, with the following composition: Bacto-peptone 5.0 gms.; Bacto-meat-extract 1.5 gms.; K_2HPO_4 3.5 gms.; KH_2PO_4 1.5 gms.; glucose 5 ghs.; and distilled water 1 liter. By adding varying known amounts of the dye to tubes of broth, inoculating with a drop of dilute suspension of the test organisms, and incubating at 32°C. it was found that all the organisms used would grow well in media

containing 10^{-4} M neutral red. More concentrated dye media inhibited some of the Gram positive types, while certain Gram negative species grew well in 10^{-2} M dye, the highest concentration used.

Aniline dyes of this type may be reduced to the colorless or leuco-form when the oxidation-reduction-potential of the solution falls below the critical potential for the particular dye. Knaysi (1935) employed neutral red in his studies because it is less easily reduced than methylene blue, methyl blue and some of the other basic vital dyes. However, in our preliminary experiments neutral red was observed to undergo reduction during the growth of a number of facultative types of bacteria such as *Escherichia coli* and *Proteus vulgaris.* This loss of dye by reduction might introduce an important error in any dye determination by colorimetric methods. Further study, however, showed that little or no dye reduction took place if the bacteria were aerated adequately by growing them in shallow layers of the dye-broth in Erlenmeyer flasks, or in the medium aerated with sterile compressed air.

To determine dye adsorption during growth, various species of bacteria were grown in 30 ml. of dye-broth medium (10^{-4} M neutral red) in 125 ml. flasks which were placed in a shaking machine oscillating sixty times per minute over a 4-inch distance. After twenty-four hours at 32°C. cell counts were made with the aid of a counting chamber. The bacterial cells were then removed by centrifugation and the concentration of neutral red in the supernatant broth determined spectrophotometrically.

In order to estimate the dye adsorbtion by the same number of bacteria under conditions where no growth occurred, two methods were used: A. Cells were grown as above but in a dye-free medium. After growth, cells were counted and neutral red was added to the flasks so that dye cell ratios were the same as in flasks with bacteria growing in the presence of the dye. After one hour the cells were centrifuged out and the amount of dye adsorbed determined by measuring that remaining in the broth. B. Cells were grown in a dye-free medium, centrifuged out, washed with distilled water, and finally suspended in sterile dye-broth in concentrations equivalent to that of the organisms grown in the presence of the dye. After standing 1 hour to equilibrate, the cells were removed and the dye concentration determined. In most cases these two methods gave concordant results; hence in the tabulated data results from method A only are presented.

Table 1 contains data obtained by growing six common bacterial species in broth containing neutral red and comparing the amount of dye

removed with that adsorbed by cells not in an actively growing state. In no instance did a greater uptake of dye occur in the growing cells. In most cases, the differences in neutral red adsorbed under the two conditions are relatively slight. No direct comparisons between the uptake by different species of bacteria can be made, since there were marked differences in the rates of growth of different species and no effort was made to maintain the same density of cell population. These results indicate that bacterial cells do not adsorb greater amounts of neutral red during growth than in a resting condition.

Table I. Per cent of neutral red adsorbed by growing cells and by an equivalent suspension of nonproliferating cells.

Organisms	Percentage of total dye removed: growing cells	cells not growing
Bacillus subtilis	91	94
Escherichia coli	47	52
Spirillum rubrum	29	33
Aerobacter aerogenes	36	48
Proteus vulgaris	40	41
Sarcina sp.	59	64

Since neutral red is a weakly basic dye, other experiments were carried out using the weakly acid vital red dye and the strongly basic dye, crystal violet, which has not been used as a vital stain. Vital red was less readily adsorbed than neutral red at the pH of the broth used in these studies, which is in agreement with results observed with other acid dyes by Harris (1949). Crystal violet was decidedly toxic to Gram positive species, so that only Gram negative bacteria were used. The results from these experiments with vital red and crystal violet agreed in all cases with the neutral red data shown in Table I. In no instance was a greater amount of dye adsorbed by the rapidly growing cells than by an equivalent number of cells in a nonproliferating condition.

When organisms are actively growing, all metabolic processes are functioning. In phsiological investigations on cellular respiration, cells are washed in a balanced salts solution and placed in a buffer solution with some respiration substrate. Under such conditions aerobic or facultative cells usually exhibit a more or less rapid oxidation of the substrate with utilization of atmospheric oxygen. Since no nitrogenous substances are present these cells can not undergo the usual rapid growth and mulplication. Hence, such suspensions have been termed "resting" cells.

While data obtained with growing cells indicated no intracellular accumulation of neutral red during growth, experiments were carried

out to determine whether "resting" cells might behave in a different manner. A heavy suspension of 24-hour old cells of *Bacillus subtilis* was washed in a balanced solution of buffered inorganic salts to remove any waste products or medium from the cells. Equal volumes of these cells were added to each of three culture tubes containing an aqueous solution of neutral red. To one of these tubes was added a complete nutrient medium; to the second, glucose and phosphate buffers but no nitrogen source; and to the third, water only as a control. These cell suspensions were aerated vigorously with sterile air for three hours at 30°C. Turbidity measurements at the end of this short incubation period showed approximately the same number of cells in each tube, indicating that little or no cell division had taken place, even in the complete culture medium. Cells were then removed by centrifugation, and the concentration of neutral red remaining was determined. Results of this experiment are shown in table II. It is evident that little or no difference in dye adsorption occurred under the three different conditions.

Table II. Percentage of neutral red combining with Bacillus subtilis cells aerated for 3 hours under three different conditions.

	Per cent dye removed
Cells, dye, and glucose	75
Cells, dye, and complete medium	68
Cells, dye, and water control	76

A third phase of this investigation dealt with a comparison of adsorption of vital dyes by suspensions of living and killed bacteria. Cells were grown in aerated broth, washed three or more times with neutral distilled water, and concentrated suspensions prepared. A portion of this suspension was steamed at approximately 100°C. for ten minutes. The suspension of killed cells was cooled to the same temperature as that of the unheated cells and the adsorption capacities of the two suspensions for a number of dyes, including some vital stains, were compared.

The experimental procedure consisted of mixing one milliliter of cells, nine milliliters of M/50 acetate buffer, and five milliliters of M/10,000 solution of the dye in water. After standing for twelve hours to reach equilibrium, the cells were removed by centrifugation and the concentration of the dye remaining was determined. The pH of the buffer mixture used in case of the basic dyes, neutral red, malachite green, methylene blue, basic fuchsin, and crystal violet, was 7.0. Since McCalla (1940) has shown that acid dyes are much more readily adsorbed at lower pH levels, the buffer mixture was adjusted to pH 5.0 for testing the adsorption of eosin Y, erythrosin B, and vital red. Typical data from these studies are shown in table III.

Table III. Percentage of total dye removed by washed cells as compared with suspensions after steaming ten minutes.

	E. coli		*B. subtilis*		*Sarcina sp.*	
	washed	heated	washed	heated	washed	heated
Eosin Y	1	2	10	32	19	22
Erythrosin B	8	49	79	85	52	60
*Neutral red	68	59	70	81	90	83
*Malachite green	36	44	49	53	62	69
*Methylene blue	75	77	75	59	89	80
*Vital red	-1	13	18	35	4	14
Basic fuchsin	62	80	69	71	66	66
Crystal violet	85	80	86	81	72	78

* Vital dyes

These data reveal some variation in adsorption of dyes by different bacterial species; however, heating the cell increased dye adsorption in most instances. Basic dyes were adsorbed in greater amounts than acid dyes. No consistent differences were observed in the rates of adsorption of vital dyes compared with others. In only a few instances was adsorption by the heated cells significantly greater than by the unheated cells. This is contrary to the theory of Knaysi that dyes do not combine with living cells. However, washing the cells with distilled water may have resulted in injury to the protoplasmic membranes of the cells comparable to the rapid cooling method of Knaysi. Cultural tests on the washed cells, however, indicated that most of them would grow in a suitable medium, even after three consecutive washings in distilled water. In general, the results of this experiment agree with those of McCalla (1940) who reported little or no difference in the adsorptive capacities of cells similarly treated.

Summary

Quantitative determination of the adsorption of neutral red, vital red, and crystal violet by a number of bacterial species during active growth, while respiring in the absence of a nitrogen source, and in an inactive state in water suspension gave no indication that the combination of the dye with the cell was related to the metabolic activity of the organism. Steam-killed cells usually gave a greater adsorption of dye than living washed cells. The adsorption of vital dyes was not significantly different from the adsorption of other basic and acid dyes.

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An Outline of Semantics for the Psychologist

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Certain writers are emphasizing the fact that the development of new forms of language and new systems of language application correlates closely with the recent rapid rate at which certain scientists have made important new discoveries. It is this attention to the significance of language in all human investigations that constitutes the field of "semantics".

It is possible that many of the difficulties of the contemporary psychologist are related to a continued reliance on antique systems of formal logic, ancient philosophy, or hand-me-down oriental or primitive mysticism. The purpose of this paper is to indicate ways in which such factors are influencing present day psychology, with the object of creating a greater awareness of the metaphysical bases of much of our current theory and practice.

The primary consideration in a paper such as this is to define the function or functions of language in scientific investigation. Korzybski (3, pp. 21-24) holds that the only possible function that words can perform is in terms of their direct influence on the inter-relationships existing between organisms and events. He illustrates this point by asking a person to define a word, any word, and then asking him to define the term or terms used in the original definition, and the terms of each successive definition, until a point is reached at which definitions either become circular (such as defining "thought" in terms of "mind" and "mind" in terms of "thought") or the response "I know but cannot tell" is given.

We suggest that language is essentially referential in nature and contains no 'meaning' of itself. All efforts at verbal definition must eventually end with a group of terms which cannot be defined further. Psychologically, language is a behavior situation in which a person refers someone (or is referred) to some object or event either vocally or by gesture (2). Language behavior is an adjustment of an individual to another individual and the object referred to: it is not a set of "symbols" that act as "carriers" for mysterious "meanings".

Language from this point of view is seen as a potential tool of science, a tool which can be of aid if the "priority of the fact" or primary datum of the science is recognized, but as Korzybski indicates, " . . . verbal levels are only auxiliary, sometimes useful, but at present often harmful (3, p. 23)." Harm results from the fact that popular language, philosophy, and formal logic are based on the universe as it was assumed to be when

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these languages originated and thus are antiquated and ill-adapted to our present day information (3, pp. 59-60). For language to be a useful tool, any science must eliminate old language habits which are known to be false or unverifiable. Some of these are as follows:

The "is of identity, which is illustrated by the following examples. If I say "This *is* a pencil.", the statement is false, for what I hold in my hand is only something *called* a pencil and no-one can know all of its details. The frequently observed responses to profane or obscene language exemplify identification, as does the not uncommon assumption that knowledge of terminology signifies knowledge of fact.

Elementalism, which indicates that certain factors which are not separable in nature can be separated verbally. The mind-body dualism implicit or explicit in most contemporary psychological theory is an illustration of the verbal splitting of unitary behavioral events. Elementalism is evident in the hypothetico-neural explanations of behavior offered by some phychologists, and is even more striking in the strictly psychic formulations of the psychoanalysts. In the former case, an attempt is made to interpret a psychological event in terms of some portion of the organism variable in the event (additionally, a psychic element is usually to be found in such theories). In the latter case, a psychological event is regarded as a manifestation of happenings in an elemental psyche which is itself separable into various components.

The subject-predicate representation, which tends to place objects in complete isolation and to ignore the fact that objects in the universe are never isolated. The penchant of psychologists either to isolate the organism variable or to give it undue emphasis in the psychological event is of this character. Even when the stimulus variable is given any importance it is traditionally regarded as an isolated object or force which activates the behavior of the organism. Seldom are the innumerable immediate and historical spatio-temporal relationships influencing the functions of both stimulus object and organism in the event complex appreciated to a significant degree.

Two-valued logic, expressed by such paired terms as true or false, hot or cold, long or short. Natural events show a continuous variation and the tendency to classify individuals into behavioral categories, when even the degree of exhibition of a specific behavior never falls into such discreet groupings, is highly artificial and of the same form as the "either-or" interpretation of two-valued logic.

The elemental postulation of cause and effect, which sought the ultimate "cause" for each observed "effect." The psychologist's job is not to seek "causes" for "effects" but to analyze the psychological event with

the purpose of isolating the variables operating in it. A case in point is the willingness of many psychologists to accept a genetic "cause" for feeblemindedness in any case where physiological trauma or pathology cannot be established. The literature is so redundant with studies showing the relationships of such variables as socioeconomic level of the home, educational level of parents, cultural deprivation, emotional problems, relative isolation, etc., to intellectual development that failure to investigate such factors cannot be defended.

"Abstract" versus "concrete," as a two-valued Aristotelian concept. The antiquated term "abstract" as the opposite of "concrete" is totally inadequate to describe innumerable degrees of abstraction which are possible. Since the events which form the data of any science are obviously so complex that no degree of observation will reveal all of their characteristics, any observation of them is necessarily an abstraction, i.e., some of these characteristics must be omitted. By the same token, any verbal report of such an observation or observations is certainly more abstract than the original observation as many of the observed details will not be included in the report. Further refinement of the data obtained will result in greater abstraction as more and more of the details are left out. It is readily seen, then, that the process of abstracting can be carried on through an indefinite series of levels or degrees and each abstraction to a higher level contains less information regarding the original observations than does the one preceding it.

As Korzybski points out, the chief value of abstracting is to save a great deal of time by describing only those characteristics of an object which are relevant to the situation. But it is of great importance to realize that high abstractions tell us only a very few selected details concerning the events involved and if we need to "know" about these events we should investigate them as directly as possible. We should never confuse orders of abstraction and assume that a high order abstract statement gives us all of the information available at a lower level of abstraction or can be compared with any abstract statement of a lower order (3, pp. 426-451).

It is common practice in psychology to refine data to a very high degree, preferably by methods of quantification. Abstractions typical of clinical practice can easily be demonstrated to be of a very high order and it may be worth while to question their practical value. An individual is abstracted from his everyday social and physical surroundings and placed in a restricted testing situation. Abstractions are taken from his behavior in this situation in such a manner that only behavior representing specific responses to test items are taken into account. The details of responses to individual test items are then omitted to such an extent as to permit a

two-valued right or wrong decision on their relative merit. The next step is to abstract the differences among right responses to test items so as to give them quantitative equivalence and then to add them together. This "raw score" is apparently still too unwieldy and is compared with large numbers of other test "scores" equally abstract in character to determine a norm. By making an equation of the individual's normative score and his chronological age a number technically known as an I.Q. is derived. Is it not probable that most of the data of value to the clinician has been lost in the process? Yet this number frequently is regarded as the only significant result of the entire investigation.

The reliance on a priori principles, which considers "reason" or "logic" to be more primary than fact.

> The truth is, of course, that it is impossible to begin work in a particular field without *some* presuppositions about its nature, and about how to set to work. The sciences arose on the basis of the preliminary work of this kind which had been done by pre-scientific thinkers, and is enshrined in common-sense. It is in connexion with methods of approach, methods of thinking and abstracting, that *demands* and hypotheses play such an important role. Some of these demands may be metaphysical in the sense that they lead us to make certain assumptions about the character of the whole field of study which cannot be put to a decisive empirical test. Instead of waiting to find out what that general character is after a good deal of work has been done, certain assumptions are made about it at the start. The history of science shows that progress has very largely depended upon the skill with which a few men of genius have grasped the kind of assumptions it was necessary to make. But these facts are by no means so widely understood as they should be, and consequently many people do not realize to what an extent such assumptions underlie scientific procedure, what their real character is, or how they have been arrived at. It is necessary that such buried assumptions should, from time to time, be dragged out into the light, in order to remind us how much our theoretical conclusions depend upon them, and to enable us to see whether they are still performing their proper functions and not leading us astray. Thus a science should be *conscious* of the assumptions and demands upon which it rests, but it seems that in natural science at the present day it is only physics—ar rather its best representatives—that can be said in this way to be 'self-conscious' (4, p. 27).

Korzybski points out that in all observations direct contact with data comes first, descriptions, ordering and inferential activity later. Thus prior observations must of necessity have preceded any postulation one may make. This "priority of fact" is also emphasized by Bridgman when he says

> The attitude of the physicist must therefore be one of pure empiricism. He recognizes no *a priori* principles which determine or limit the possibilities of new experience. Experience is determined only by experience (1, p. 3).

He illustrates the dangers of absolutist principles by showing that all measurement is approximate in character and that we have no clear cut knowledge about anything. Because of this uncertainty surrounding all our investigations an empirical science can make no exact statements and must at all times be prepared to revise its formulations to include new observations (1, pp. 33-35).

Korzybski offers a quotation from E. T. Bell (3, p. 188) which illustrates the predicament of the "scientist" who cannot accept such provisional formulations.

> Nevertheless, the consuming hunger of the uncritical mind for what it imagines to be certainty or finality impels it to feast upon shadows in the prevailing famine of substance.

As an alternative to *a priori* principles and a futile search for absolutes, the following working postulates for the psychologist are suggested.

1. Psychology, in common with other sciences, is concerned only with space-time events.

2. The data of psychology consist of behavioral events. The two primary variables of the behavioral event are the interacting organism and stimulus object.

3. Behavioral events are ontogenetic; i.e. they are serially evolved and elaborated during the course of interaction between the variables involved.

4. In common with other sciences, descriptions and interpretations of behavioral events must be derived from observation of those events and must be referable to them.

5. "Internal principles" or attempts at elementalistic interpretations of the behavioral event in terms of some part of it are rejected.

6. "*A priori* principles" or attempts to interpret the behavioral event prior to observation of it are rejected.

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Changing Orientations Toward the Role of Physiological Factors in Psychopathology

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It is the thesis of this paper that here and there contemporary psychotherapy reveals a changing orientation toward the role of the physiological factors in psychopathology. Current medical literature stresses the need for even the general practitioner's attending to such non-tissue conditions as "mental, nervous and emotional factors in health, illness and convalescence" (1, p. 1135). Some therapists indicate that exclusive concern with a patient's anatomical structures may cure a lesion but "fail to meet the total problem of the patient" (4, p. 1158) and urge a holistic approach toward medical data.

Lidz and Whitehorn (9) have recently gone so far as to reverse the traditional "no psychosis without a neurosis" and have been able to isolate psychological factors which they consider as "causal" in hyperthyroidism. In a series of 15 thyrotoxic patients, "almost all patients were found to have suffered a serious emotional crisis prior to the onset of the illness, which was critical because it struck at the core of the weakness in the personality configuration" (p. 699). What a far cry from the Kraepelinian undying faith that when more powerful microscopes were built every psychological ill would reveal a specific lesion. It was such hints as the preceding that stimulated a more thoroughgoing review of the medical literature to which we now turn, although lack of sufficient time imposes restriction of subject matter to a consideration of the role of the brain in psychopathology.

Folklore and every-day language are replete with phrases that connect behavior with a variety of anatomical spots. Thus, anger is related to the spleen, love and courage with the heart although we also memorize or learn "by heart," the bowels are connected with compassion and the phrases, "he has a good head on him" or "he is a brain," attest to the aged faith in the head as the seat or organ of mind.

On this point, we can not improve on Anderson's (2) statement which we quote at length:

> Man's old belief that damage to the vital centres profoundly upsets the balance of the personality finds some support from careful psychiatric observation; man's common belief that any blow to these centres must produce far-reaching changes is not substantiated, but the notion dies hard. Patients commonly entertain the notion that the head is a fragile box filled with precious

objects, such as thought, and vaguely defined vital centres. After an injury the resulting change in the personality and capacity for work is attributed to damage to the contents of the box, and the complaint of headache is in many cases a response to the patient's discontent with his own emotional and intellectual capacities, though defects of these may have been present before the injury. Now he can explain why he has failed: "I have a headache."

In Anderson's study of 150 consecutive patients admitted to a neurosis center in whom head injury was held responsible for the symptoms, there was, first of all, a wide variety of reactions indicated rather than a single syndrome. More important still, in some cases, physical trauma played no part whatsoever and the patient simply blamed his difficulty on the alleged injury. In others, head traumata were considered only as precipitating factors in the development of neurotic and psychotic reactions while in the rest, the psychopathology had a more definite biological basis.

For some time, Schaller (14) has been pointing out that the examining physician may be an important factor in the patient's sudden development of a neurosis following a head injury.

> An unguarded statement as the severity of trauma or outlook for recovery, if this carries the idea of any doubt, may precipitate a psychoneurosis. Treatment of the neurotic person for his original injury is often unduly prolonged without the suspicion that his symptoms are mental in origin (p. 1784).

At the same time, Schaller indicates that whether or not there is actual brain damage makes little difference in the development and evolution of a neurosis. In either case, the patient's personality make-up and a desire for recovery and return to work may overcome adverse and uncomfortable situations sufficiently to permit good adjustment. Schaller is of the opinion that a neurotic patient may receive compensation for "defects in character and temperament rather than for injury" (14, p. 1782), the injury simply serving to exaggerate the predominate character traits of the neurotic patient. Schaller, furthermore, is of the opinion that unsatisfactory work relations reinforce and prolong psychoneurotic complaints and suggests that

> The treatment of a traumatic psychoneurosis is to recognize its onset at the precipitation point and to make it unpopular and unprofitable. In none of my cases of post-traumatic psychoneurosis do I recall a single instance of the condition following injury to boys at play or in college athletics, boxers, wrestlers or jockeys (p. 1583).

When it is realized that 23 of 100 patients with definite concussion made no complaint of headache while "headache is an almost constant complaint of the psychoneurotic patient" (14, p. 1783), then one begins

to realize that the human organism must be considered in his cultural milieu rather than as so much skin and bones.

Among others, Halstead (8, p. 480) has pointed out the lack of specific knowledge regarding the alleged dependence of the higher mental functions on particular structures of the brain. In view of the wide acceptance of the brain dogma, the following quotation from his writings is pertinent.

> The failure of many individuals to exhibit obvious signs of mental impairment and social incapacity following mild or severe damage to the brain has been rather generally noted.

On the other hand, Wortis, Herman and London (15, p. 280) write bewilderingly as follows:

> The mental disturbances in acute subdural hematomas are the most striking neuropsychiatric findings. Some patients with minimal neurologic disturbances often have marked mental disturbances.

Regarding the relationship of the brain to behavioral performance, Schaller (14, p. 1779) also states in the language of a by-gone age: "Physicians do not know the neural mechanisms which produce unconsciousness or indeed, the anatomic seat of consciousness."

Despite such frank confession of a lack of knowledge concerning the brain's imputed psychological functioning, both traditional psychology and psychotherapy have clung to the belief that *future* investigators would eventually bring such knowledge to light. Thus, this theory marches onward.

One of the difficulties standing in the way of a proper evaluation of brain damage has been the lack of dependable criteria. Lynn, Levine, and Hewson (10, p. 296) have argued that the common complaints and indices that constitute the chronic post-traumatic general head syndrome "can apparently be produced by histogenic or psychogenic mechanisms, either alone or in combination" and that

> despite the widespread opinion of the high frequency of occurrence of . . . intellectual defects in the late post-concussional period, no systematic, adequately controlled or objective studies of the matter have ben made (p. 305).

The weakness in this technique has been that such behavioral indices as loss of consciousness or degree of deterioration have often been used to infer anatomic damage!

Similarly, Ruesch, Harris and Bowman (13, p. 507) have shown that, although an extensive literature deals with surgical, neurologic or psychologic aspects of head injuries,

> No clear-cut answer regarding the influence of the pre-

> traumatic personality on the development of post-traumatic syndromes could be found.

These investigators reasoned that if the post-traumatic personality was primarily determined by the type and extent of brain injury, then there should be uniform personalities in similar injuries. However, if such variables as educational, economic and social conditions as well as pre-traumatic personality were involved, then relationships with these factors should be apparent! Specifically, the study was meant to answer the following questions:

> What kinds of people have head injuries?
>
> What personality features characterize them?
>
> What are the relationships of the post-traumatic personality to the nature of the injury and to the pre-traumatic personality?

Forty patients (the acute group) were seen within four weeks of cerebral injury. Seventeen patients were examined from one to twelve months following injury and 62 cases had injuries more than a year. These 79 cases were called chronic. Severity of brain injury was determined by six criteria known to be indicators of extent of brain injury. Complaints commonly obtained from patients with head injuries were secured by typing 48 such statements on single cards which the subjects were asked to sort into true or false categories.

The results showed a differential frequency related to various groups of head injuries. With a mean of 13.4 complaints, chronic patients surpass the acute groups, with a mean of 8.9 complaints. Furthermore, the acute cases show that their complaints are related to the brain damage. Thus, mild injuries show an average of two complaints, moderate ones 5.5, the severe 11.8 and complicated injuries 17. Cases with neurological signs show more complaints than those without such signs. However, chronic cases show a reversal of this trend in that mild and moderate injuries show 14.9 complaints as compared with 12.4 for the severe and complicated ones. In this group complaints are not related to the brain damage.

> Cases with post-traumatic syndromes with a duration of one year or more have the largest number of complaints in spite of the fact that all patients with neurologic signs were excluded from that group (13, p. 523).

The group was administered the Minnesota Multiphasic and according to psychiatric histories was separated by clinical judgement into pre-traumatic "normal" and "maladjusted." Again, results indicate that maladjusted sub-groups within both acute and chronic cases scored higher on almost every scale than those classed as normal. Furthermore, chronic cases that had complaints for more than a year *in absence of neurological findings,* when compared with other chronic cases scored significantly higher on all

the neurotic scales. Their highest score occurred on the hypochondriasis scale and was almost four standard deviations above the norm. A few more comparisons of a socio-economic sort between the acute and chronic cases are presented here in tabular form.

	Acute	Chronic
Mean income per year	$1282	$2125
Childless individuals	73%	35%
Single individuals above the age of 30	24%	3%
Frequency of childhood neuropathic traits	30%	67%
Divorced or separated	35%	11%
Frequent job changes	39%	13%
Unemployed more than half time	24%	4%
Frequent change of occupation	25%	3%
Slum dweller	49%	19%
No interests	33%	10%
Dependency for more than one year in last 5 pre-traumatic years	33%	5%
Mean age	48	35

The authors interpret the above facts to mean that social maladjustment seems to be related to proneness toward accidents. For example, lack of family ties as shown by the higher percentages of childless, elderly, single and divorced individuals may well lead to carelessness and over-exposure to everyday dangers. The chronic group consists of a higher proportion of neurotic individuals as shown by the high incidence of "neuropathic" personality traits in childhood. It is these factors that facilitate prolongation and exaggeration of post-traumatic reactions, "These individuals seem to be unable to cope with their minor problems and make the injury the 'cause' of this inability" (13, p. 536). The higher frequency of complaints as well as their vague unlocalized character distinguish these patients from those of the acute group.

> One must conclude that what the people are like before the injury determines what they are going to be afterwards. The factors of injury and brain damage seem to be of secondary importance only (13, p. 538).

Findings of a similar sort occur in a military setting from a study by Everts and Woodhall (5, p. 145) who have observed that patients with mild head injuries are more likely to complain of "headache, dizziness, insomnia, irritability and trouble in concentrating than those receiving a more severe injury." As in other studies, immediately after injury, complaints show a relationship to brain damage and are proportionate to the severity of the injury. Subjects with a certain personality make-up may become symptom free within a few months when their injuries are light or moderate. Those with a certain other pre-traumatic personality continue to show "symptoms." Everts and Woodhall (5, p. 148) suggest that early progressive activation and early return to light duty is the best form of management for the soldier with closed head injuries thus preventing the development of compensation neurosis in the more emotionally unstable members of this group.

Further light on the proper role of the biological factors comes from a study of 521 patients with chronic headache reported by Friedman, Brenner and Carter (6). A group of 334 patients had headaches as reactions of anxiety, depression, resentment or frustration to conflict or stress situations, and showed no trauma or other laboratory evidence of biological involvement. In this "psychogenic" group the cranial circulation or musculature entered as a participating factor in a behavioral response to a stress situation. The other (post-traumatic) group of 187 subjects experienced headache following head injuries. Four hundred and ninety-four subjects were treated by a combination of psychotherapy and pharmacotherapy and 27 by psychotherapy alone. The drugs used included analgesics, vasoconstrictors vasodilators, hormones combined with vitamins and placebos. The percentages improved in each group are as follows:

	Analgesics	Vasocon-strictors	Vaso-dilators	Hormones and Vitamins	Placebos
Psychogenic patients	73%	49%	51%	58%	57%
Post-traumatic patients	70%	44%	50%	58%	63%

In our opinion, the outstanding result is the high percentage of improvement in medication with purely inactive substances under the placebo category. In both psychogenic and post-traumatic groups the respective percentages of 57% and 63% compare favorably with definite medication of the variety used with the exception of analgesic. Phychotherapy alone showed improvement in 59% of patients whereas psychotherapy plus analgesic medication gave a percentage of 71% improved. But since placebos themselves gave a high percentage of improvement, medication must not be considered as a "purely physiological" variable. Friedman, *et al.* (6, p. 197) say as much when they point out that the effectiveness of medication depended to a certain extent on the physician prescribing it, the time spent with the patient and the frequency with which he was seen. Many patients showed improvement when seen at weekly intervals but would have a relapse when seen at monthly intervals instead. Disability compensation and litigation also played a part in the post-traumatic cases. It would seem then, that even pharmacotherapy cannot be divorced from its psychotherapeutic aspects which is essentially what these authors say when they write

> the effectiveness of symptomatic treatment is primarily caused by the patient's psychologic reaction to the treatment situation in general and in particular to having received a "remedy" from the physician (6, p. 197).

Conventionally and traditionally, migraine has been considered as a headache of unknown (but presumably brain) origin. Recently Marcussen and Wolf (11) suggest that therapy in migraine might better be directed to prevention and reduction in the frequency and severity of recurrences

rather than to treatment of the individual attack. As a program for achieving that end, they suggest that

> Migraine occurs in a setting of life situations and attitudes which result in accumulated emotional tension and fatigue. Therefore, more important in the treatment of such a patient is the identification of the stressful factors in his life which lead to the phenomena of this attack (p. 198).

It would not appear to be too far a departure from Marcussen and Wolff's formulation to treat migraine as an anxiety reaction in a behavioral situation in which (apparently) intracranial vasoconstriction plays a secondary role. Clear up the tension reaction and the patient no longer has to react in the migraine way to that painful vasoconstriction. By such reorientation 2 out of 3 patients have been helped in terms of reduction in the severity and frequency of headache. It is hardly necessary to point out that the older theory of migraine as the manifestation of alleged brain spots was fruitless.

In his study of cases of head injuries at Boston City Hospital, Denny-Brown (3) has observed that traumatic dementia did occur where advanced age and alcoholism were prominent factors and although continuing to follow up such cases has recently concentrated his inquiry on fresh cases not complicated by these conditions. Writing of the latter group of patients, Denny-Brown (p. 471) asserts

> It is remarkable that no case of persistent dementia has yet occurred in 119 cases of all types of head injury in healthy non-alcoholics between the ages of 15 and 55 and followed up for six months or longer, without evidence of pretraumatic improvement.

Finally, we come to the behavior of seniles and its relationship to their brain conditions. In this area, Rothschild (12) has done both careful research and critical thinking. He has criticized workers who take the narrow stand that structural damage to the brain is the only factor of importance in arteriosclerotic psychoses and suggests that studies already carried out have shown that when the anatomic factors were weighed without any preconceptions as to their significance, it was evident that they were only a fragment of the total picture and that factors of a more intimate nature were of etiologic importance.

Challenging the theory prevalent since Alzheimer that the cerebral changes associated with arteriosclerotic psychoses wholly explain the psychoses, Rothschild undertook a detailed study of 28 psychotics with complications of cerebral arteriosclerosis. These patients ranged in age from 48 to 86 years at the time of death and consisted of 21 men and 7 women none of whom had shown previous psychotic disturbances.

Cerebral alterations were prepared in sections stained by the Nissl method and studied by microscopic examination.

> In only a few cases were the cerebral changes so widespread that one might be inclined to stress the quantitative factor; in many instances the alterations were not extensive. There was no consistent correlation between the severity of the mental changes and the extent of the anatomic involvement. For example, the structural damage observed in patients with severe intellectual impairment was sometimes less pronounced than that observed in patients with much milder mental symptoms. These discrepancies occurred too frequently and were too striking in certain cases to be dismissed as unimportant. They could not be accounted for by differences in the localization of the process or the type of involvement. Thus, a scrutiny of the data without preconceived ideas indicates that even the impersonal aspects of the psychosis cannot be adequately explained by anatomic considerations alone.
>
> Elderly patients with manic-depressive or schizophrenic psychoses often showed cerebral vascular changes which were as extensive as those observed in the group with arteriosclerosis, but reliable clinical correlations could not be established.
>
> There was nothing in the observations to support the view of Alford that "intellectual defect per se is not produced by lesions other than those of the central portion of the left hemisphere in right-handed persons" (p. 431).

Rothschild (12, p. 436) concludes that the relationship between extent of neuro-pathologic changes and degree of intellectual deterioration revealed numerous discrepancies which did not permit an easy anatomic explanation. Cerebral lesions do not inevitably produce psychotic disturbances. As an alternative, he suggests that attention be directed to qualities of the living patient as an important factor in the origin of this behavioral maladjustment.

We bring this review of medical studies to a close with reference to a study by Gallinek (7, p. 293-294), which starts with the challenge that

> What is labelled as senile and arteriosclerotic psychoses is not as simple and unequivocal as originally assumed by Kraepelin. It is also noteworthy that the concept of the straight, simple, unequivocal causal relationship between senile or arteriosclerotic brain pathology and the corresponding type of psychoses included automatically a poor prognosis and resigned therapeutic attitude. Among 230 consecutively treated patients, Gallinek (7, p. 296)

administered electroconvulsive therapy to 36 patients 60 years of age and over, the oldest being 84 years old. According to standard psychiatric classification, these patients would have been diagnosed as psychosis with cerebral arteriosclerosis or senile psychosis. Behaviorally, depression, paranoia and agitation were outstanding complaints. Most patients received less than ten treatments yet "in the overwhelming majority good and lasting results were achieved (p. 296).

Gallinek concludes that such results argue against the traditional theory of a close, causal relationship "between the undoubtedly irreversible pathologic (anatomic) changes of senile degenerative and arteriosclerotic nature and the psychoses" (p. 301). For him a constellation of variables is operative, one element of which is a pathologic anatomic factor but this one element is not adequate for precipitating a psychosis nor does the continued presence of such an anatomic condition stand in the way of a clue. At best, it interferes with the individual's adjustment to a situation which must also consider such conditions as bad breaks, financial insecurity, loss of affection, prestige, etc.

We believe that the implications of the several studies here reviewed are clear and strong. In our opinion they point to the necessity of dealing with maladjustments not as morbid processes occurring inside the person's brain or alleged mind but in a broader context as the reaction of a living person to other variables found in domestic, economic, social, sexual and other life situations. We believe that such a view can give proper emphasis to presence or absence of biological conditions as preventing or facilitating sets of sub-variables localized in the anatomical and physiological make-up of the organism which happens to be involved in behavioral situations. They are neutral and become no more nor no less important than any other variable but certainly surrender their role as "causal" factors in human maladjustment. Such an event orientation would also indicate a freer therapeutic approach than the narrow one traditionally focussed inside the skin of the organism.

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Relationship of Mean Scores on the Strong, Kuder and Bell Inventories with the MMPI M-F Scale as a Criterion.

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Problem

The clinical experience of the authors in their work with objective self-appraisals of interests and personality has led to the observation that relationships exist among measured characteristics of personality which were not evident in a previous factorial analysis. In this previous study four selected instruments, the Minnesota Multiphasic Personality Inventory, the Strong Vocational Interest Blank for Men, the Kuder Preference Record, and the Bell Adjustment Inventory were analyzed for factors common to thirty-four scales scored.[1] Specifically, a relationship was thought to exist between the M-F scale of the MMPI and certain scales of the Strong, Kuder and the Bell which is concealed in simple intercorrelations among these variables in an unselected population. Thus, we are concerned with the hypothesis that despite these low intercorrelations, when the MMPI M-F key is used as the criterion for selection, relationships between this key and others will demonstrate that there is a common tendency toward those activities involving interest in people and social situations. In a sense, of course, this is simply one way of validating the low but significant correlations found. This paper is a note on the pilot study conducted to investigate the value of testing this hypothesis.

The problem is to determine whether significant differences exist in mean scores of two samples populations selected by using the M-F scale of the MMPI as a criterion.

Population

Two samples were drawn from a population of veterans of World War II who requested testing under the V. A. advisement programs at a large eastern university. The greater part of these subjects were applying for training or jobs at the professional level. The two groups are equivalent with respect to age, grade completed in school, academic ability as measured by the Otis Self-Administering Test of Mental Ability, Higher Form A, and veteran status as shown by frequency of P. L. 346 and P. L. 16 applicants, though they differ in their degrees of dispersion on these variables.

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Table I. A Description of the Samples

Variable	Experimental Group		Control Group		V_e	V_c	F*	t**
	N	Mean	N	Mean				
Age	47	23.8	48	23.4	17.18	8.53	2.01	.09
I.Q.-Otis SA Higher Fm. A	46	119.3	47	115.4	296.12	422.71	1.43	.99
Grade Completed	47	13.3	48	12.4	1.81	9.94	5.49	1.76

* An F value must equal or exceed 1.603 to be significant at the .05 level, 1.934 at the .01 level.
** A t-ratio of 1.987 reaches the .05 level of significance for these d.o.f., and 2.632 at the .01 level.

The control group includes 50 subjects whose scores on the twelve keys of the MMPI were within the normal range, i.e., within plus or minus two standard deviations of the mean, with the M-F scale a T-score of 50 or below.

The experimental group consists of 50 subjects whose scores on eleven keys of the MMPI are within the normal range but whose T-score on the M-F scale equals or exceeds 65.

Procedure

Means and variances were computed for 24 variables for each of the two samples. Variances were compared for homogeneity and the probability of the difference between means was computed by using Student's t-ratio[2] for six group and three non-occupational keys of the Strong Vocational Interest Blank and the ten scales of the Kuder Preference Record. The probability of distributional differences on the four scales of the Bell Adjustment Inventory was determined by a chi-square test.

Results

Homogeneity of the variances of the two samples is assumed for all scales but Groups II and X and the M-F key of the Strong, where in each case homogeneity is doubtful. A significant difference of means was found on the Kuder mechanical, literary, musical and M-F scales, a possible difference was found for the Strong Group V, and (assuming homogeneity of Variance) there are differences on the Strong Group X and M-F keys. For the remaining scales of the Kuder and Strong, the null hypothesis was not rejected. On the Bell a chi-square test gives evidence for rejections of the null hypothesis on the home and emotional keys, the possibility of difference on the health key, and no evidence of difference on the social scale. This is shown in Table II.

[2] Selected levels of significance for the variance ratio are a value at/or above the 5% level, which indicates failure to reject the null hypothesis concerning homogeneity of variance and at the 1% level rejection of the hypothesis. The intermediary range is a doubtful zone. For Student's *t* the 1% level is considered sufficient evidence for rejection and a value that fails to reach the 5% level is considered insufficient evidence for rejection.

Table II. The Comparison of the Samples

Variable	Mean of deviate Group N=50	Mean of Non-deviate Group N=50	Variance of Deviate Group	Variance of Non-deviate Group	F	t
MMPI						
M. F.	30.52	18.08	4.34	3.95	1.099	30.52
Strong*						
Group I	175.66	176.16	1697.86	1561.36	1.087	.06
Group II	177.48	198.44	3010.09	4930.09	1.638	.53
Group V	232.05	213.46	1241.67	1409.76	1.135	2.55
Group VIII	207.0	207.6	617.96	493.31		2.55
Group IX	220.44	218.78	1341.99	1195.48		
Group X	179.44	158.44	2558.33	1399.44	1.828	2.36
O. L.	249.76	244.74	2972.58	2256.81		
I. M.	327.14	305.14	5862.61	8892.90	1.517	1.28
M. F.	205.5	262.9	3462.88	5669.97	1.637	4.25
Kuder						
Mech.	55.06	71.24	463.00	374.10	1.238	3.96
Comp.	32.72	33.70	158.37	142.34		
Sci.	53.58	65.26	238.33	310.52	1.303	1.12
Pers.	82.46	81.76	537.27	528.02		
Art.	44.44	45.38	234.66	237.14		
Lit.	62.2	50.5	399.92	280.42	1.426	3.17
Mus.	22.18	14.98	73.05	52.84	1.382	4.53
Soc. Serv.	75.70	76.08	350.38	422.24	1.205	.95
Cler.	54.92	51.60	352.73	262.82	1.342	
M. F.	58.88	75.92	668.32	958.43	1.434	2.99
Bell Adj.			Degrees of Freedom	Chi-Square	Probability	
Home	5.78	3.08	7	15.63	<.02>.01	
Health	7.02	5.06	6	10.80	<.10>.08	
Social	8.06	7.14	6	1.84	<.95>.92	
Emotional	9.28	4.82	9	30.25	<.01	

an F value: ≧ 1.60 is at or less than .05 level of significance.
≧ 1.94 is at or less than .01 level of significance.

a t-ratio: ≧ 1.987 is at or less than .05 level of significance.
≧ 2.632 is at or less than .01 level of significance.

Scores on the Strong Blank include a constant of plus 200 to eliminate minus scores.

Conclusions

Where a high score earned on the M-F scale of the Minnesota Multiphasic Inventory is used as a criterion for selection, male veterans are seen to exhibit a greater objective sensitivity to their environment and an increasing warmth of feeling for others. They seem to be interested in people and language, to like reading and music, and to dislike activities involving the manipulation of material objects. It is conjectured that persons selected on the basis of the factor or factors measured by this key will display concomitant aspects of personality and interest as they are measured by objective instruments. There is here an implication that some stereotypy among personalities is an actual phenomenon.

In diagnostic testing for the purposes of educational-vocational counseling, it would appear reasonable for the clinician to appraise each of these variables as corroborative evidence for and against specific goals within the personal contact areas. Many of us in the work of personnel and guidance have independently learned to watch for just such relationships.

Notes on the Ground-Water Resources of Chase County, Kansas

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Chase County is located in the heart of the blue stem Flint Hills region of east-central Kansas (Fig. 1). Physiographically it is a part of the Osage Plains section of the Central Lowland Province (Fenneman, 1938), a plain of low relief characterized by a series of east-facing limestone escarpments. The most prominent of the escarpments is called the Flint Hills because of the occurrence of several thick massive limestones with abundant chert and flint, which are primarily responsible for the hills.

Within Chase County ground water occurs in two different manners, (1) as free unconfined ground water under true water table conditions and (2) as combined ground water. Wells obtaining water from alluvium

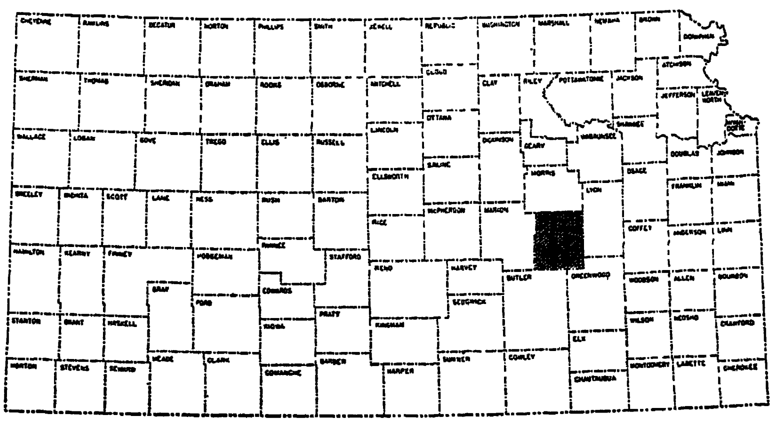

Fig. 1. Map of Kansas showing location of Chase County.

in the valleys and from the terraces along the valley sides encounter free ground water but wells deriving water from the Permian rocks may obtain either free ground water or confined ground water.

The near-surface rocks of Chase County are Permian or younger in age (Fig. 2). The oldest Permian rocks which crop out at the surface are those of the West Branch shale formation. Successively younger Permian rocks crop out up to and including rocks of the Wellington shale formation. Terrace gravel deposits of Pliocene (?) and Pleistocene age occur along the sides of the major stream valleys, and alluvium of Pleistocene to Recent age occurs along each of the principal streams.

Wells obtaining ground water from Permian rocks derive it almost entirely from the limestones of the Council Grove and Chase groups. Very

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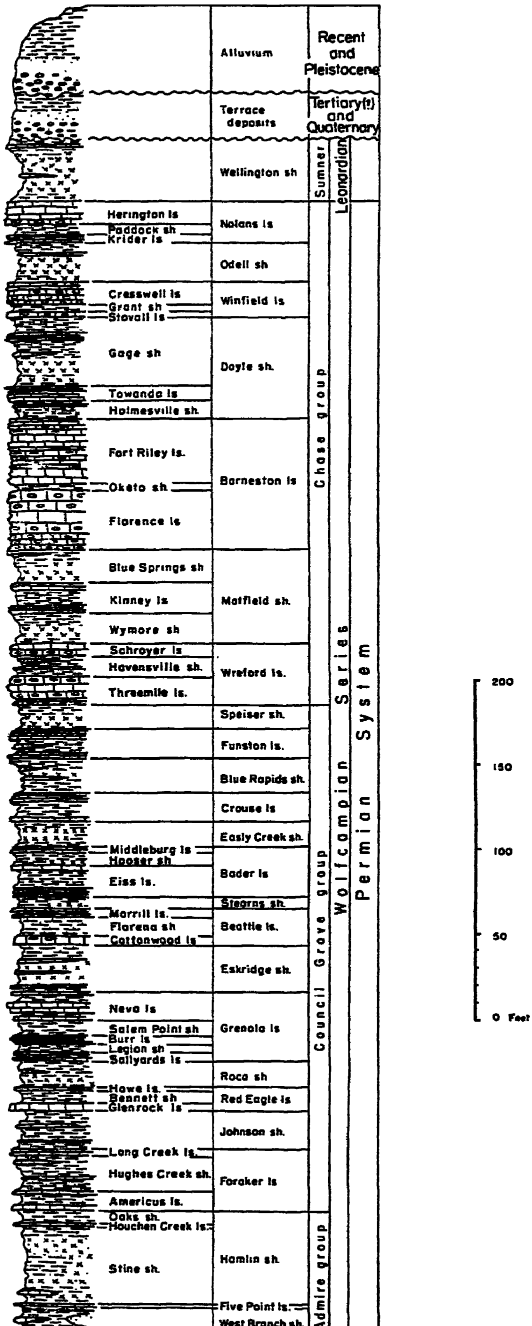

Fig. 2. Generalized section of the exposed rocks in Chase County, Kansas.

little sandstone is exposed or present in the near-surface rocks. Water in the limestones occurs along joints and bedding planes, in solution channels, or in secondary deposits of permeable material filling joints in shales. A few wells possibly obtain water from leached gypsiferous zones in shales.

The rocks of the Admire group, principally shale with some limestone and sandstone, are the oldest Permian rocks which contain potable supplies of water, but are of limited areal extent and are not known to contain any valuable aquifers. The Towle shale, Aspinwall limestone, Hawxby shale, and Falls City limestone of the subsurface in Chase County consist of shales, thin impure limestone, and mudstones, none of which would yield much if any water to a well. Throughout almost all the county any water they might yield to wells would be too highly mineralized to be useful for stock or domestic supplies.

The West Branch and Hamlin shale formations are principally colored and sandy shale with a small amount of sandstone. The Five Point limestone separating the two shales is a hard, dense, gray limestone about 2 feet thick and is of little importance as an aquifer. In this area rocks of the Admire group thus may be classed as extremely poor sources of ground water.

Rocks belonging to the Council Grove group overlie the Admire group and contain several limestones which yield water in sufficient amounts to make good stock and domestic wells. The principal aquifers in this group are the Beattie and Grenola limestones, and to a lesser extent the Red Eagle, Foraker, and Bader limestones. Other formations in this group also supply water to wells but are not as dependable or as adequate for a well supply.

The lower member of the Beattie formation, the Cottonwood limestone, is a massive light-buff to white, porous limestone 4 to 6 feet thick which has prominent vertical joints and generally one or two horizontal partings. In many parts of the county this limestone, in addition to its numerous joints, has a well-developed system of solution channels rendering it more porous and permeable. The upper member of the Beattie formation, the Morrill limestone, commonly supplies lesser amounts of water to wells in which the Cottonwood limestone is the principal aquifer. In some instances, however, the Morrill limestone is the principal aquifer. The Beattie formation is probably the best aquifer of the Council Grove group and supplies many stock and domestic wells.

The Grenola formation, which contains the Neva, Burr, and Sallyards limestone members, is another important aquifer in areas of

Chase County where it is not too deeply buried. The Neva limestone, averaging about 17 feet in thickness, is composed of three principal limestone beds separated by thin shales. The middle limestone bed is the most massive and forms the characteristic prominent Neva bench over the countryside. This bed is massive, porous, light-buff limestone which weathers pitted, very rough, and gray. It is believed to be the chief water-bearing zone of the Neva. The Burr and Sallyards limestone members are not as massive or prominent as the Neva but are platy, thin-bedded, and shaly. Water occurs chiefly in the joints and bedding planes of these limestones.

The Glenrock limestone member of the Red Eagle formation in some areas of Chase County is about 6 feet thick, massive, finely porous to cavernous, white, and is a good aquifer. However, the thickness of the Glenrock is not uniform, being only 2¾ to 3 feet in some areas. The Howe limestone member is an oölitic and foraminiferal limestone 1 to 3 feet thick, part of which is soft, porous, and has solution channels.

Beds classified as the Foraker formation are the lowermost rocks of the Council Grove group. The Americus and Long Creek limestone members are sources of a few small springs and wells in the eastern part of Chase County and in the vicinity of Elmdale.

A rather persistent geodiferous to cavernous zone of celestite, calcite, and quartz occurs near the top of the Long Creek limestone in Chase County and in areas to the north. A few wells obtain good supplies of water from rocks believed to belong to this zone.

One other limestone, the Eiss member of the Bader formation, supplies water to wells in parts of Chase County. Generally, however, the yields are small and the wells may fail in periods of deficient rainfall. Because of their topographic position with respect to the escarpment-making Wreford limestone and their generally dissected nature, other limestones, such as the Crouse and Funston formations, are poor sources of water in Chase County.

The Chase group overlies the Council Grove group and contains the most important bedrock aquifers within the county. Both the Wreford and Barneston limestone formations are excellent sources of good domestic and stock water supplies where they occur over considerable area undissected by streams.

The Wreford limestone, about 33 feet thick, consists of two limestone members and a separating shale member. The upper Schroyer limestone member is commonly a very cherty limestone with a nonflinty zone in the upper part. The lower member, the Threemile limestone, is cherty in its upper and lower parts and contains a massive noncherty or

sparsely cherty zone near the middle. This noncherty zone produces a strong bench along its line of outcrop and numerous solution channels and cavernous zones occur along it. Large yields are sometimes derived from wells penetrating cavernous zones in the Wreford formation, especially in the southwestern part of the county.

The Florence limestone member of the Barneston formation similarly is a cherty limestone about 37 feet thick. Most of this limestone is exceedingly cherty but a noncherty zone which occurs near the middle is generally observed to be quite permeable and cavernous.

The overlying Fort Riley limestone consists of thick, chalky, porous limestone and calcareous shale about 40 feet thick. It is hard and massive in some outcrops and soft and shaly in others.

Where either the Wreford or Barneston formation is undissected over a considerable area wells penetrating them may be expected to produce good yields of water. Large amounts of water not now utilized by wells are discharged naturally in the southwestern part of the county. Wells yielding 10 to 25 gallons per minute are common and yields of 50 to 100 gallons per minute can be obtained.

In the lower part of the Doyle shale formation the Towanda limestone, about 9 feet thick, is traversed by numerous small faults and fractures and is a good water-bearing limestone. In the southwestern part of the county numerous wells penetrate both the Towanda and Fort Riley limestones and obtain water from each. The two limestones are separated by about 10 feet of Holmesville shale.

Because of considerable structural changes in the various beds in the southwestern part of the county, the quantity of water available at different places varies widely. Generally speaking, however, this part of the county is well supplied with ground water.

The Winfield limestone formation supplies a few stock and domestic wells in the area around Wonsevu, but is limited to a few square miles in extent. Beds above the Winfield are of little value as aquifers in Chase County because of the small area in which they occur.

It is to be emphasized that when obtaining water from limestone aquifers the success of any well is dependent upon the number and size of interconnected openings in the zone of saturation which the well penetrates. These openings may be joints, fractures, bedding planes, solution channels, or cavernous zones.

Terrace deposits tentatively classed as Pliocene (?) and Pleistocene in age, composed for the most part of coarse chert gravel and overlain by sandy red and reddish-buff silt and clay, occur along the sides of the major stream valleys. These deposits, occurring chiefly along the north

side of the Cottonwood River Valley, are most extensive in the area between Strong City and the east boundary of the County. Considerable terrace material occurs also along the west side of the lower part of the valley of the South Fork of Cottonwood River. All of the major streams and most of the small streams and creeks cut through the terraces to bedrock, thus draining most of the gravel. However, there are a few areas in which shallow wells utilize ground water from terrace material.

Alluvium, ranging in thickness from a few feet to 55 or 60 feet, occurs in the Cottonwood River Valley and its main tributaries and contains good supplies of water. Wells properly constructed in the areas of maximum thickness of alluvium are capable of yielding 75 to 150 gallons of water per minute without excessive drawdown. Correspondingly smaller supplies are available from alluvial deposits along the smaller tributaries. The municipal water supplies for Strong City and Cottonwood Falls are obtained from wells in the alluvium of the Cottonwood River Valley.

Springs and seeps occur along almost every limestone in the county at one place or another but a few limestones, generally the better water-bearing beds, are characterized by green vegetation and shrubs growing along their outcrops. The largest springs are found along the outcrops of the Wreford and Florence limestones. Table 1 lists four of the larger springs in Chase County, the flow of which was measured or estimated in the fall of 1947.

Table 1. Chart showing name and location of four springs in Chase County, together with measured yields (a) and the name of aquifer.

Name of spring	Location	Flow, in gallons per minute	Aquifer
Palmer Spring	SW NE sec. 7, T. 18 S., R. 8 E.	75(b)	Threemile limestone
Rock Spring	SE NE sec. 9, T. 21 S., R. 7 E.	34	Florence limestone
Jack Spring	SW NW sec. 25, T. 22 S., R. 7 E.	95	Florence limestone
Perkins Spring	Lot 6, sec. 19, T. 22 S., R. 8 E.	70	Threemile limestone

(a) Measured by W. W. Wilson, October 29, 1947.
(b) Estimated flow, September 20, 1947.

Of interest also is the occurrence of flowing wells in two localities. Three small flowing wells occur on the William Selves ranch in the NE¼ SE¼ sec. 27, T. 20 S., R. 7 E. and two small flowing wells occur on the J. C. McNee ranch, one in the SW¼ SE¼ sec. 34, T. 20 S., R. 7 E., and the other in the NE¼ NE¼ sec. 3, T. 21 S., R. 7 E. All five of these small wells derive water from the Wreford formation at a depth of 100 to 150 feet and are on the southeast flank of the Elmdale anticline.

The second locality is on the Morse farm in the SE¼ SE¼ sec.

27, T. 22 S., R. 6 E. This well is approximately 30 feet deep and is believed to derive water from the Fort Riley limestone. Originally this well was reported to have had a head of about 13 feet, although it was considerably less than that in the fall of 1947.

In regard to the chemical quality of the water within various aquifers, most of the waters are moderately hard to hard, the Wreford and Barneston formations generally supplying water of the best quality.

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The Whitetailed Jackrabbit

(Lepus campestris)

R. E. MOHLER, McPherson College
RICHARD H. SCHMIDT, Canton, Kansas

The whitetailed jackrabbit, prairie hare, or jackass hare as it has at times been called is becoming a rare specie in Kansas, yet older men of this generation who lived in central, western, or northern Kansas were familiar with this interesting animal. At the present time it appears that the only sections of Kansas where this rabbit is found is in the extreme northwest corner of the state and there infrequently.

The specimen, a picture of which was shown at the 81st meeting of the Academy was killed in Thomas County in 1929. So far as we have record this is the latest date for one having been killed in this section of the state.

In the book *American Animals* by Witmer Stone and W. E. Cram (New York, 1920), this animal is reported to occur from Iowa and Minnesota west to the Sierra Nevada mountains and from central Kansas north to Saskatchewan. While in the book *Name That Animal* by E. C. Driver (Northhampton, Mass., 1942), the habitat is described as from Iowa west. It is doubtful if either description as to location should be considered as correct today, as the animal has gradually retreated to the north and west during the past fifty years.

Transactions
Kansas Academy of Science

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Wartime Advances in Yellow Fever and the Rickettsial Infections

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We are privileged to present the following interesting review of advances in man's eternal warfare against disease. The distinguished author of this review is a native Kansan and received her training in Kansas schools. During the war, Dr. Downs served as civilian expert in one of the top secret research projects at Camp Detrick, Frederick, Maryland. Since the war, she has been the co-ordinator of one of the most extended and ambitious research projects ever carried on in the state—a study of immunity and transmission of tularemia and for which a special virus laboratory was constructed at the University of Kansas.—The Editor.

The necessities of war always result in an application of many basic scientific principles which have been worked out in individual laboratories and which might not have practical application for years except for urgent need. Such urgent need leads to the cooperative efforts, the tremendous pouring out of funds, and the ingenuity which results in great scientific advance. I am not sufficiently informed nor would I have space to tell you of all the advances in the field of medical bacteriology which took place in the years from 1938-1947, so I will try to tell something of the work that was done in one virus disease, yellow fever, and in four of the rickettsial diseases, typhus, Rocky Mountain Spotted Fever, American Q fever, and scrub typhus.

It was after the Spanish-American war and in great part due to the informed interest of a great soldier and physician, Doctor Leonard Wood, that in 1900 an American army commission under Walter Reed was appointed to study yellow fever. These men proved beyond doubt that yellow fever was caused by a filterable virus and that it was carried from man to man by the *Aedes aegypti* mosquito. It seemed for a while that the eradication of yellow fever was a simple matter of mosquito control and we rested comfortably on this assumption which seemed to be borne out by the disappearance of yellow fever from our southern states, from Havana, and from our success in protecting the builders of the Panama Canal.

The virus itself was elusive since we had no way to cultivate it in a test tube and we knew of no animal which was susceptible. In 1925, Noguchi had described an organism supposed to cause yellow fever and since it was known that a broad band of yellow fever country extended across Africa, the Rockefeller Foundation established laboratories in Acra near Dakar and at Entebbe in the Uganda. It was in Acra in 1928 that Noguchi died of yellow fever after finding that the organisms he had described were not the cause of yellow fever but instead were the cause of a type of jaundice. In this same year at Acra, two Americans (1), Bauer and Hudson, and a young Englishman, Stokes, discovered that the virus could be transmitted to rhesus monkeys. Stokes, also, died that year in Acra of yellow fever, one of the many victims claimed by this once deadly disease. Thus we had at last an experimental animal, a great step forward in the investigation of any disease.

The next ten years were filled with significant studies. The virus was adapted to mice in 1935 and to embryonated eggs in 1937. The virulence of the virus was decreased by serial passage in tissue culture and many attempts at the preparation of a vaccine were made. Another significant date in this story is that of 1933 when endemic yellow fever was recognized in South America (2). It was shown that yellow fever was carried by jungle mosquitoes, *H. capricornus,* and others. It was also shown that monkeys, marsupials, and other animals possessed antibodies for the virus and might be supposed to be hosts. Here then was a different story from the simple eradication of a domestic mosquito, breeding only in the vicinity of houses and carrying the disease from man to man. The united efforts of zoologists, entomologists and medical men could not be expected to eradicate whole jungles full of mosquitoes and mammalian hosts.

In addition, the world was shrinking rapidly with the spread of air travel. Mosquitoes from Africa or South America could easily arrive in this country or Europe during their infective period. Men bitten by infected mosquitoes could be flown in before they came down with the disease and could constitute a source of infection in the area where they landed provided that the suitable mosquito existed there.

This state of affairs existed at the beginning of World War II. What would evidently be needed for any expeditionary force going into yellow fever areas was a reliable specific vaccine. Such a vaccine had been made possible by Goodpasture's discovery in 1931 (3) that many viruses grow well in embryonated eggs. Theiler (4) had already shown that the weakened virus could be grown in the mouse brain and a vaccine could be prepared from this preparation; but imagine the difference of cost and labor between making a supply of vaccine from mouse brains for an army and making a vaccine from embryonated eggs. The egg vaccine was tried out

and shown to be successful in field trials in South America so that by the summer of 1940 the Rockefeller Foundation was beginning to set up laboratories for the production of yellow fever vaccine in quantity and by the time we were in the war, every man who went into yellow fever areas was vaccinated.

This vaccine was prepared from an attenuated strain of virus. The virus is grown on young embryonated eggs and because the virus deteriorates so rapidly, the egg material is harvested at high speed and dried while frozen at —70° C. The first batches contained human serum as a stabilizer and were the cause of many cases of infectious jaundice because of a virus contained in certain of the human serum used. The serum was later replaced by water, the so-called aqueous base vaccine, and this danger was eliminated. Two and one-half million men were vaccinated. The results of vaccination were excellent. Although our men went into yellow fever areas, only a few cases resulted and there were no deaths; a fine achievement built on years of painstaking and sometimes seemingly unrelated bits of scientific data. Without laboring the idea, it might be pointed out that the vaccine is a safeguard to those who travel to and from infected areas and even without the eradication of mosquitoes and mammals would decrease incidence of the disease by decreasing the number of susceptible hosts.

The four rickettsial infections, typhus, Rocky Mountain Spotted Fever, Tsutsugamushi or Japanese river fever, and Q fever, I have chosen to discuss are of interest to bacteriologists, entomologists and zoologists because in each of them the etiological agent is rickettsial and is transmitted from man to man by an arthropod bite, that is the bite of lice, ticks or mites respectively, or is transmitted from animal hosts to man by an arthropod. These rickettsia vary in size, shape and properties but they all refuse to grow except in the presence of living tissue. It was not, therefore, until the advent of Goodpasture's use of the embryonated egg in 1931 that they could be easily cultivated.

The disease, typhus fever, has been known and feared for centuries. It has various significant names such as ship fever, jail fever, famine fever, hospital fever. It is known in two forms, epidemic typhus which is the classical form of typhus and endemic or murine (rat) typhus. Epidemic typhus is borne from man to man by the body louse and it has decimated armies and the dislocated civilian populations of warring countries for centuries. It caused the death of 17,000 persons during the siege of Granada in 1489 and it has continued its evil way through the modern Spanish Civil War and World War II. Wherever men are crowded together and are dirty, hungry, and cold, there you find typhus. We find endemic foci of this disease in the highlands of Central and South America,

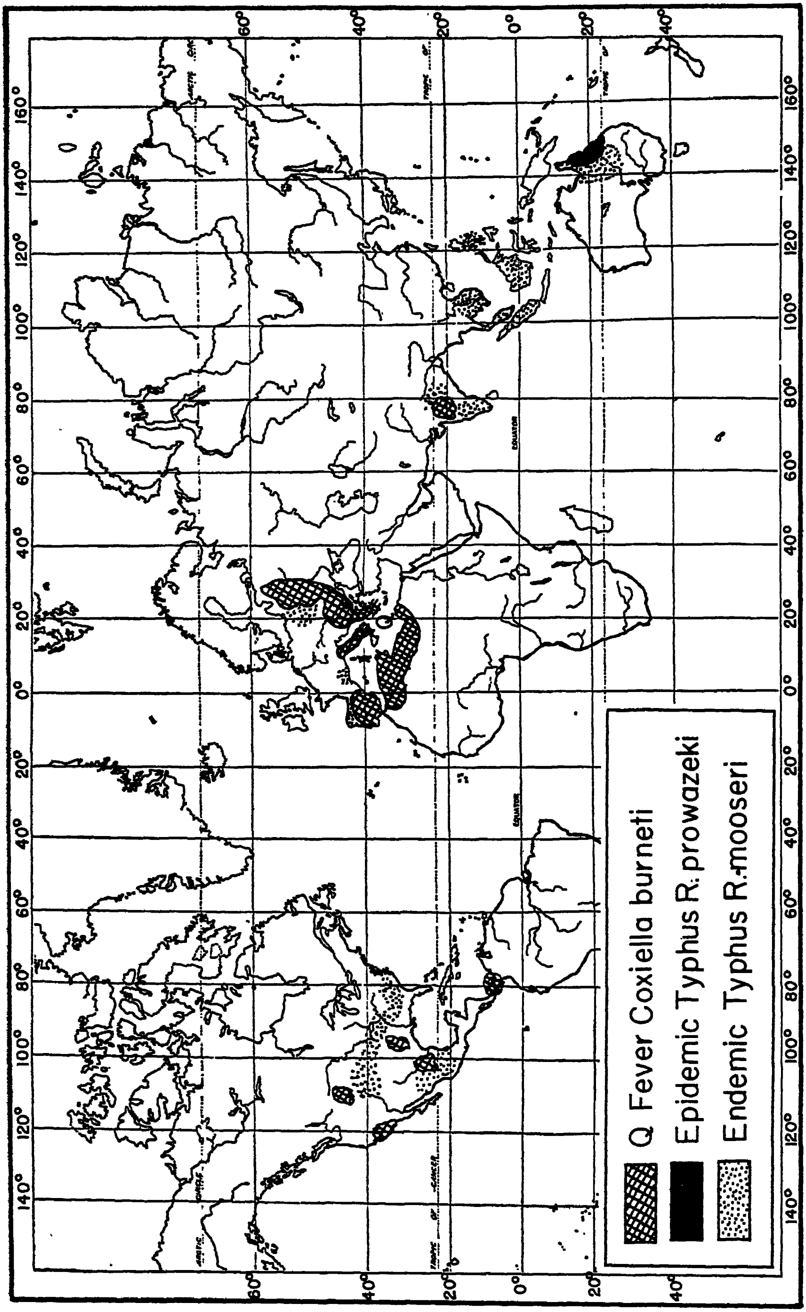

Q Fever Coxiella burneti
Epidemic Typhus R. prowazeki
Endemic Typhus R. mooseri

FIG. I

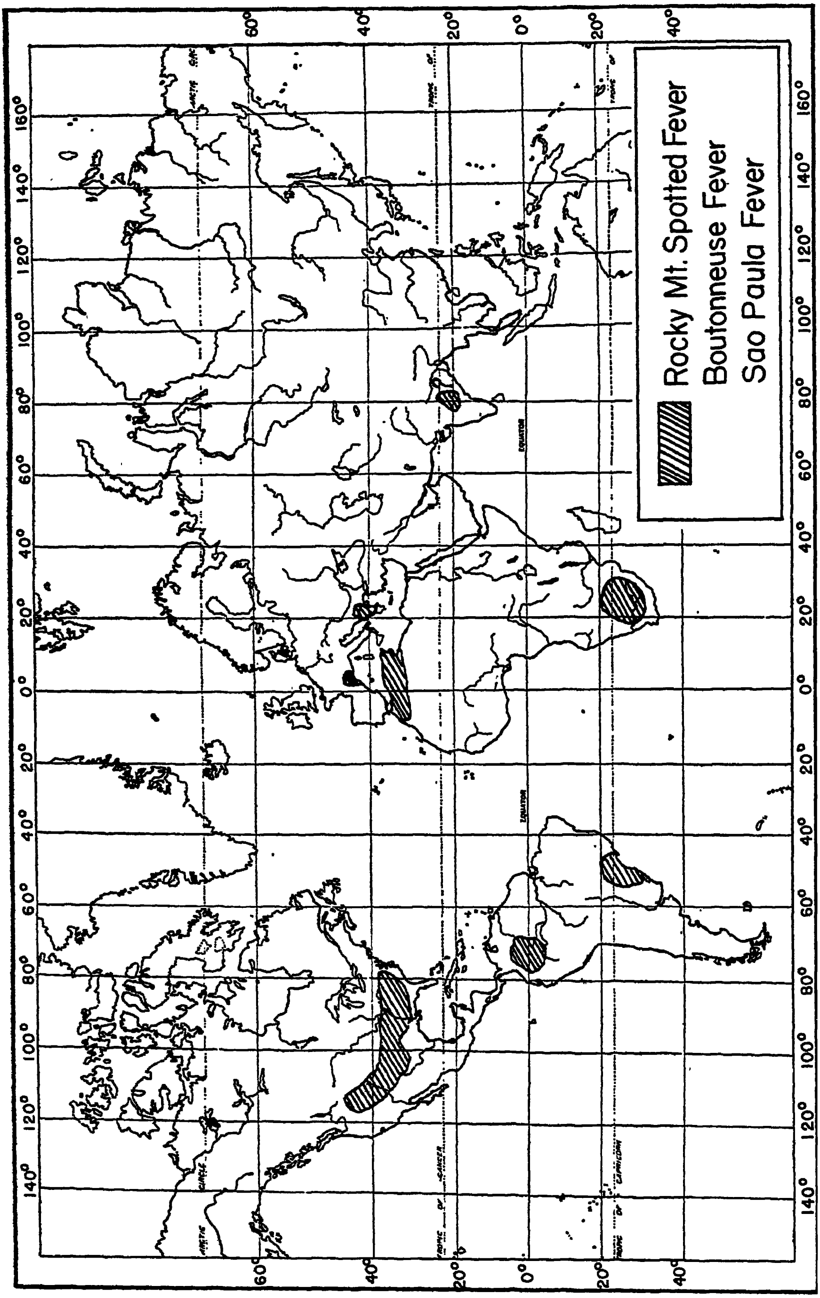
North Africa and some parts of Central and South Africa, in Spain, in parts of France and Germany and in the Balkan states, Russia, Turkey, Iran and Iraq and in Afganistan and China. The causative agent was first described in 1916 by da Rocha Lima who had proved the transmission of the disease by the body louse in 1909. A glance at the map (Figure I) will show the importance of this disease to the Allied Armies in World War II. Before 1939, a number of vaccines had been prepared. Weigl had made vaccines from artificially infected lice and incredible as it may seem, these vaccines, requiring 120-175 lice per human dose were used to vaccinate Germany army officers. Zinsser and Castenada (5) and others had prepared vaccines from organism grown in rats and had given them a limited trial in South America and in Spain. The evidence seemed to be that they had definite preventive value. However, in 1938, Cox (6) at the Hamilton, Montana, United States Public Health Service Laboratory, observed that the typhus rickettsia grew abundantly in the yolk sac of embryonated eggs and prepared vaccines from this source which were highly protective. These vaccines were used in the British and American armies and although they did not entirely prevent typhus, they seemed to make the disease much milder than the classical type seen in unprotected persons.

The use of DDT to kill body lice as used by the army in Italy was, also, definitely an aid in decreasing the incidence of typhus; not only in the troops but also in the civilian populations.

I think we may feel that never again will typhus be the scourge that it has been in the past, provided our whole mechanism of civilization does not break down.

I will spend little time on the less important endemic typhus except to say that the variety of its names tells you much about its distribution. It is called New World typhus, endemic typhus of Australia, Greece, Syria, Manchuria, Moscow, Urban typhus of India, Toulon typhus, shop typhus of Malay. This is the typhus spread from rat to rat by the flea and rat louse and from rat to man by the rat flea. Where rats are, there is endemic typhus. The vaccine against epidemic typhus gives some protection against murine typhus but the best bet is the elimination of rats.

A glance at Figure II also shows the distribution of Rocky Mountain Spotted Fever. Now you may wonder why Rocky Mountain Spotted Fever has any bearing on World War II but this name includes a group of fevers caused by rickettsia and which occurs well distributed over the world. In South America, they call it San Paulo fever; in South Africa, Kenya fever or Tick borne fever of South Africa and India, around the Mediterranean it is called Fiévere boutonneuse. This disease is carried to man by a variety of ticks and although there are animal reservoirs in nature (dogs, sheep

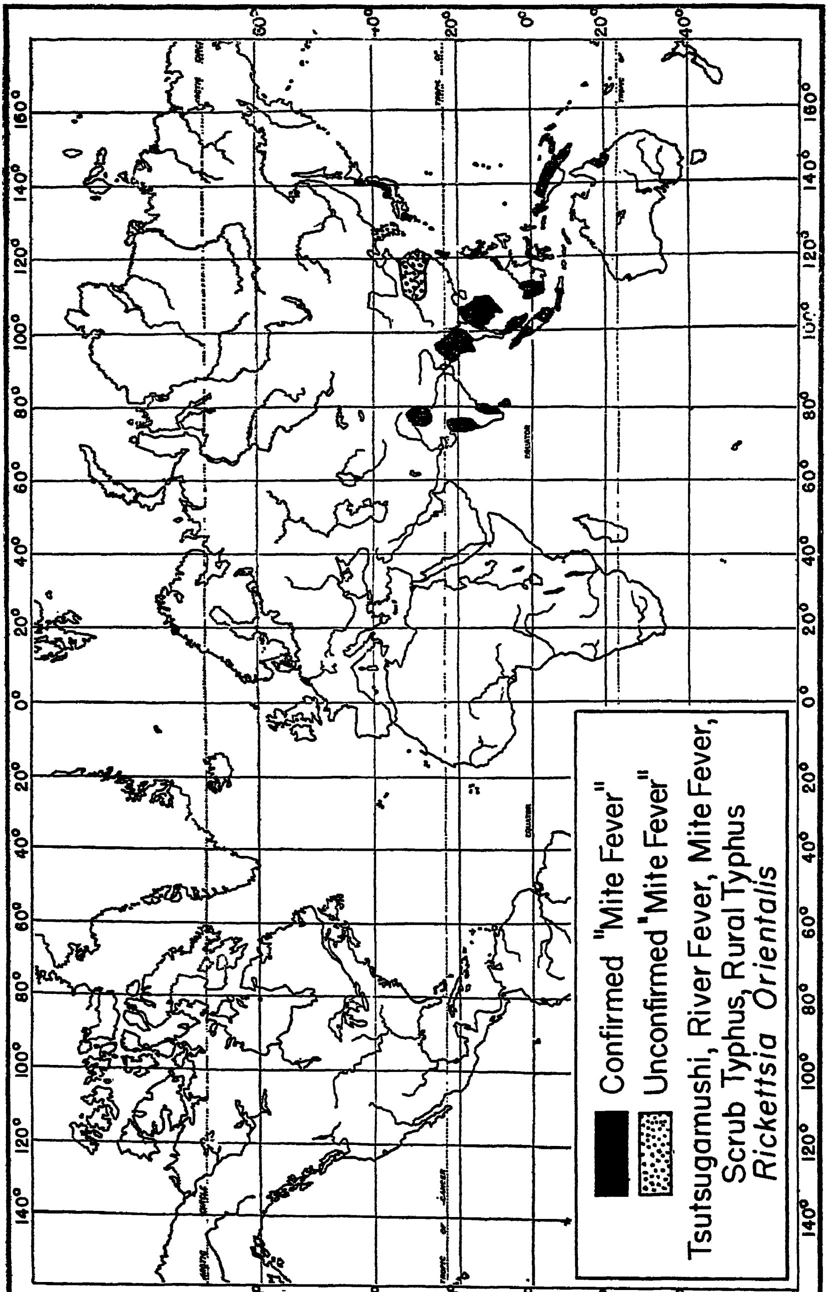

Rocky Mt. Spotted Fever
Boutonneuse Fever
Sao Paula Fever

and rodents), it is not necessary that such a reservoir exist, since the tick can carry the disease from generation to generation. Vaccines made from infected ticks are prepared as well as vaccines from infected yolk sacs. As far as I know these vaccines were not necessary for wide use during the war. They are, however, of considerable use where special occupational hazards exist as in sheep herders, forest workers in the Rockies, etc.

The story of Q fever is an interesting one (Figure 1). In 1937 Derrick (7) described the disease in cattlemen in Queensland, Australia, and Burnet (8) subsequently studied the causative agent. In 1935, Davis and Cox (9) described a new species of rickettsia from ticks collected along Nine Mile Creek in Montana. The causative agents from Australia and from Montana turned out to be identical. Human cases in this country were not known until several laboratory infections occurred but now it is known that cases have resulted from tick bites in Montana. Until well along in the war, most people supposed that the disease was confined to the United States and Australia, but in 1941 forty-three cases were found to occur in troops quartered in southern and northern Italy and in Greece where the Germans called the disease "Balkan flu". We now know that cases have occurred in Illinois, California, Texas and Panama. So it is entirely likely that it has a much wider distribution than was dreamed of at first. The animal reservoirs are probably cattle, dogs, bandicoots, opossums, and other animals. The disease is known to be transmissable to man by the bite of ticks but the source of the Italian cases is far from clear and may point to some other arthropod vector. A vaccine has been prepared and favorable results have been reported but this vaccine must still be considered to be in an experimental state.

Last of all, I would like to tell you briefly about some of the work done during the war on tsutsugamushi disease, known also as scrub typhus, Kedana fever, Japanese river fever, rural typhus and Sumatra mite fever. (Figure III.) At the beginning of the war, a great deal of confusion existed as to the identity of these diseases and it was largely due to the team work of entomologists, zoologists and bacteriologists and medical men with the typhus commissions of the United States and British Armies that the confusion was cleared up.

It was found that the various diseases were one and the same: all caused by rickettsia now called *Rickettsia orientalis* and transmitted to man by the larval form of a mite belonging to the trombiculid family. These mites are found in grasslands along rivers and in swamps and attach themselves to passing animals for a blood meal. The adult form does not feed on animals but the organisms persist in the adult stage and are passed to the next generation through the eggs, so that the larvae of the second generation may infect animals. Wild rodents of various sorts act as


Confirmed "Mite Fever"
Unconfirmed "Mite Fever"
Tsutsugamushi, River Fever, Mite Fever,
Scrub Typhus, Rural Typhus
Rickettsia Orientalis

reservoirs of the disease and the rickettsia have been isolated from them. It is possible to produce a vaccine for this disease but not enough opportunity has been presented to be clear as to its value. The best prevention is probably protective clothing and if possible avoidance of infected areas.

With the advent of the antibiotics the records of brilliant cures from their use in bacterial infections flooded the scientific journals. The records of their use in rickettsial and virus diseases was not nearly so satisfactory until Doctor J. E. Smadel (10) found that scrub typhus could be treated successfully with chloromycetin. The whole routine of scientific investigation was pursued by Smadel and his associates. This compound was tried on the rickettsia in infected eggs, then on infected animals. It was found very effective in these tests and so it was tried out on human cases in New Guinea. These cases responded at once in a spectacular manner and the use of one antibiotic was established as a treatment for a rickettsial infection. The use of streptomycin and penicillin in virus and rickettsial infections in general has been much less satisfactory than the above mentioned use of chloromycetin.

Aureomycin, another recently described antibiotic, promises to be a valuable drug in the treatment of rickettsial infections. Recent reports (11, 12) have shown that this drug has a limited activity against virus infections but is a good therapeutic agent in experimental rickettsial infections and has been used with some success in rickettsial infections in man.

To summarize then, a successful vaccine is obtainable for yellow fever but no new therapy has been evolved; effective vaccines have been developed from the rickettsia of typhus and spotted fever and probably Q fever. A new treatment involving the use of antibiotics, chloromycetin and aureomycin has been tested in cases of *Rickettsia orientalis* infection and in typhus and spotted fever, as well as in Q fever and promising results have been obtained.

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The Editor's Page

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ROBERT TAFT, *Editor*

If ever there is a logical occasion for a sermon, it seems to the editor, it is at that time when the year is nearly spent. Those of us who reflect at all may wonder about the logic of past events and their effect on the future; more likely, however, we view with discouragement our own feeble part in those events.

Doubtless we all feel at times, that our efforts are futile, our thoughts are non-existent or of little value, and our influence negligible. Especially in a day when the world is so distraught, when every day we read of new alarms, of new failures in the progress toward peace, or of news particularly disconcerting to our sense of well-being, do we tend to disparage the worth of the individual. History, or experience, suggests, however, that even the most humble of us can set a course toward a goal that will realize some satisfaction.

The world has known troublous days in times past but if history does repeat itself, a period of relative calm will again be eventually reached. If we can trust this natural law, however puzzling or however distressing is the current day, each one of us can make the attempt to work calmly with what intelligence and persistence we possess on the work which is our lot.

If order, justice, and friendliness seem lacking in the world about us, some contentment for the individual can be realized by contributing these factors in the accomplishment of the immediate tasks that lie before each one of us.

* * *

We present in this issue our third annual summary of the enrollment of college students in Kansas colleges and universities. As in previous years the data has been secured directly from each of the twenty-two senior colleges and twenty junior colleges through the kind co-operation of the respective registrars of each institution. As can be seen, the total enrollments for 1949 are down from the 1948 figures by less than three per cent. But such a cursory statement does not reveal all of the trends. Enrollments in junior colleges are actually above last year's figures as they are for a number of senior colleges. The greatest decreases for the current year, both relatively and actually, are in the largest institutions.

In fact, this trend appears to be nation-wide, for the New York *Times* of November 27, 1949, in commenting on their own poll taken from all colleges and universities point out that smaller institutions, community colleges,

and technical schools shown gains in enrollment, but large state institutions and well-known private colleges reported decreases in enrollment of five to ten per cent. Further, the country-wide total shows a small net increase over the 1948 enrollments.

As a result of their survey, the *Times* makes the flat prediction that *college enrollments will continue at present levels, with slight fluctuations, for another five years.* A high water mark in enrollment is to be achieved, the *Times* believes, about 1960.

If college enrollments have therefore stabilized, the ever occurring problem of financial support for our greatly expanded institution is becoming progressively more and more acute. Temporary makeshifts have appeared in some form on the campus of almost every college in the land. Temporary class-rooms, temporary laboratories, temporary barracks and even temporary instructors have been added to the equipment of our institutions. But how long is *temporary?* Will this temporary equipment be sufficient?

Still another aspect of such tem-

Enrollments in Kansas Senior Colleges

		Fall, 1947	Fall, 1948	Fall, 1949
1.	Baker University, Baldwin	640	667	690
2.	Bethany College, Lindsborg	420	406	382
3.	Bethel College, North Newton	439	416	397
4.	College of Emporia, Emporia	312	335	292
5.	Fort Hays Kansas State College, Hays	981	979	1,019
6.	Friends University, Wichita	576	525	547
7.	Kansas State College, Manhattan	7,158	7,432	7,032
8.	Kansas State Teachers College, Emporia	1,362	1,441	1,488
9.	Kansas State Teachers College, Pittsburg	1,899	1,844	2,004
10.	Kansas Wesleyan University, Salina	515	529	474
11.	McPherson College, McPherson	459	408	368
12.	Marymount College, Salina	266	265	261
13.	Mt. St. Scholastica, Atchison	401	394	369
14.	Ottawa University, Ottawa	580	583	535
15.	St. Benedict's College, Atchison	486	529	515
16.	St. Mary College, Xavier	375	370	390
17.	Southwestern University, Winfield	701	608	559
18.	Sterling College, Sterling	321	273	257
19.	Tabor College, Hillsboro	352	237	240
20.	Washburn Municipal University, Topeka	1,919	2,020	1,962
21.	Wichita Municipal University, Wichita	3,032	3,164	3,390
22.	University of Kansas, Lawrence and Kansas City	9,486	9,751	8,758
	Totals	32,680	33,176	31,929

Enrollment in Kansas Junior Colleges

1.	Arkansas City	236	215	225
2.	Central College, McPherson	105	105	84
3.	Chanute	242	220	186
4.	Coffeyville	482	361	459
5.	Dodge City	219	205	210
6.	El Dorado	281	223	222
7.	Fort Scott	267	200	165
8.	Garden City	129	151	183
9.	Hesston	187	113	184
10.	Highland	96	68	45
11.	Hutchinson	476	430	398
12.	Independence	300	244	279
13.	Iola	92	90	124
14.	Kansas City	684	548	438
15.	Paola (Ursuline College of Paola)	104	120	133
16.	Parsons	266	239	297
17.	Pratt	125	152	161
18.	Sacred Heart, Wichita	81	70	128
19.	St. John's Lutheran College, Winfield	257	226	286
20.	St. Joseph's, Hays	21	25	5
	Total Junior College Enrollments	4,650	4,005	4,212
	Total Senior College Enrollments	32,680	33,176	31,929
	Grand Total, College Students in Kansas Colleges	37,330	37,181	36,141

porary equipment is the ever-present fire hazard that its use almost inevitably brings. For the most part, these temporary class-rooms, laboratories and barracks are of flimsy frame construction and the tragedy which struck the University of Oklahoma campus a few weeks ago when a temporary barracks was consumed in flames must have brought shudders of apprehension to many campuses the country over.

Yet a few days before the University of Oklahoma tragedy, 50,000 spectators assembled in its stadium to watch their football warriors take the field. On the average, each of these spectators probably paid something like ten dollars apiece—for transportation, meals, liquor, tickets—to see the game. A half-million dollars, enough to build a fire-proof barracks, was thus "raised" in the course of a day. The editor, although naive, isn't naive enough to believe that all 50,000 spectators would willingly give ten dollars apiece for any such purpose as a new college building, but the main point of the argument is that there is money in large quantity available. How to extract it—painlessly or otherwise—so that our institutions can maintain adequate staffs, plants and equipment to take care of our huge college enrollments is one of the major problems of the day.

Scientific News and Notes of Academy Interest

Items for this column are solicited from all Academy members. For inclusion in any given issue they should be in the editor's hands at least three weeks before our publication date, namely the fifteenth of March, June, September and December.

The 82nd annual meeting of the Academy will be held at Wichita on April 13, 14, and 15, 1950. Make your plans now to attend.

Progress is being made on the new Mound Valley (Kansas) Agricultural Experiment Station authorized by the last legislature. The Station will be under the supervision of Mr. F. E. Davidson, who is to be in charge of soil fertilization studies. Two other technically trained men, one for dairy husbandry and one for crops, will also be added to the staff. Construction has been started on the buildings of the Station which will comprise 282 acres in Labette County, in the southeastern part of the state. The special objective of the Station will be the determination of the relationship between soil and crop quality and the nutrition of dairy animals.

Dr. F. C. Gates will represent the Academy at the AAAS meetings during the Christmas holidays. A report of his activities—or some of them at least—will be given in a subsequent issue.

The meetings of the two national entomological societies at Tampa, Florida, during mid-December drew a number of Kansas members. Drs. Paul A. Dahm, P. F. Bonhag, and Roger C. Smith of Kansas State College, Manhattan, and Drs. H. B. Hungerford and Charles Michener of the University of Kansas, were in attendance.

Mr. Gene Larson, who was graduated from Bethany College in

1946, is serving as instructor in biology at Bethany during the current year.

Dr. G. H. Duerksen, for the past five years on the research staff of the Phillips Petroleum Co., Bartlesville, Okla., joins the staff of Tabor College in January. Dr. Duerksen, who received his doctorate in chemistry from the University of Kansas in 1942, will teach in the division of physical sciences and mathematics.

Dr. Philip F. Bonhag, assistant professor of entomology at Kansas State College, Manhattan, recently received a research award of $485.00 from the American Academy of Arts and Sciences. Dr. Bonhag will utilize the award in a study of certain aspects of the micro-anatomy of the horse fly including the central nervous system, skeleto-muscular mechanisms and changes in structure accompanying activities of the secretory tissues.

We regret to report the death on October 8, 1949, of Dr. Otto Treitel of the University of Pennsylvania, and a member of the Academy since 1943. Dr. Treitel, a frequent contributor to these *Transactions,* was born at Karlsruhe, Germany, May 16, 1887, and spent the major portion of his life in Germany. When the Nazis came to power he was thrown into a concentration camp and the rigors of his confinement contributed no doubt to his untimely end. He finally escaped from his captors and for the last ten years has been resident of this country. Although a physicist by training, Dr. Treitel had become interested in plant physiology and his contribution to the *Transactions* dealt with various aspects of elasticity and plasticity in living plants. An additional biographic note on Dr. Treitel appears in our March, 1945, issue, page 328.

Dr. A. D. Weber, professor of animal husbandry at Kansas State College, Manhattan, on January first becomes associate director of the Kansas Agricultural Experiment Station and associate dean of the Agricultural School. Dr. Weber will be succeeded as head of the department of animal husbandry by Dr. Rufus F. Cox, since 1930 a member of the Kansas State staff.

The Yearbook of Agriculture for 1949 contains 944 pages of interesting and useful information about trees. For excellent reasons the Secretary of Agriculture in the foreword expresses the wish that every American might have an opportunity to read the book. As a poet once sang, "the groves were God's first temples", so we may now conclude that trees are among man's greatest benefactors. This fact alone would justify the publication of the 1949 yearbook. The book contains 128 popular articles by recognized authorities and a 180-page supplement containing tree-identification keys, a vacation guide, a woodsmen's glossary and an index. The articles cover such subjects as man's relation to trees, trees and homestead beautification, forest ecology, tree production on the farm and in the forest, forest ownership (the privately-owned commercial forest land in the United States is in the possession of 4,225,706 owners), forest enemies (insects, diseases, parasites, fire), forest wildlife, the uses of wood, forests and streamflow, and forestry as a profession. The book is replete with excellent illustrations. Of all the fine Yearbooks of Agriculture,

this one on trees is one of the best. It is published by the Government Printing Office, and may be obtained at $2.00 a copy from the Superintendent of Documents, Washington 25, D. C.; or if you are not too late you may obtain your copy, *gratis,* from your senator or representative.—F. D. Farrell.

Professor L. R. Lind of the University of Kansas has recently published a translation of the famed *Epitome of Andreas Vesalius.* The importance of this work is brought out in the review which follows, a review prepared for readers of the *Transactions* by Dr. Paul G. Roofe, professor of anatomy at the University of Kansas.

The Epitome of Andreas Vesalius, translated from the Latin with a preface and introduction by L. R. Lind, with anatomical notes by C. W. Asling and a foreword by the late Logan Clendening, the MacMillan Company, New York, XXXVI, 103 pp. (Latin Text), 1949, $7.50.

The late Doctor Logan Clendening remarks in his foreword that: "Here, indeed is the epitome of one of the greatest works on science ever to be written; one of the foundations of modern civilization." Osler had made similar remarks about the *Fabrica.*

One is amazed that such a jewel of scientific literature should not have appeared previously in English translation. It had a very early translation into German and Dutch, but into no other modern tongue. Professor Lind is to be highly congratulated for such a superb translation, and the MacMillan Company for the beautiful format of the book with its Latin text which contains all of the meticulous wood cuts of the original illustrating the compendium.

Vesalius intended the epitome to be a compedium, a very brief descriptive anatomy designed to be used by the medical profession and the lay public. "Clearly, Vesalius wished to reach as wide a public as possible by means of the Latin and German texts of his manual with the hope of forestalling as well as he could plagiarists whom he knew were inevitable." Its wide acceptance and use is attested by the fact that today there are twenty known copies available. This translation which uses a very fine American idiom, faithfully employs modern technical phraseology.

The *Epitome* is an independent book—a book in its own right, written in such a way that there is no repetition of the *Fabrica.* It is a marvelous piece of condensation. "The tone of the Epitome is sober and impartial; Vesalius never mentions his contemporaries by name and scarcely refers even to Galen, except in the dedicatory epistle." The date of its publication marks the beginnings of modern objective science. It remains along with the *Fabrica* the basis of modern human anatomy. The present translation carries with it excellent anatomical notes by Dr. C. W. Asling appended at the end of each chapter.

The present volume is publication No. 21, Historical Library, Yale Medical Library. The book is dedicated to the late Logan Clendening, professor of history of medicine, University of Kansas. Not only will this book be of value to the student of the history of medicine, but to all those interested in morphology in all its aspects.

The translator's introduction presents the life and work of Vesalius in a brief but fascinating manner.

A discussion of the *Epitome* is treated critically. The bibliography is not extensive, but references lead one to all that is known about Vesalius, especially Harvey Cushing's—"A Bio-Bibliography of Andreas Vesalius." "Vesalius to the reader" precedes the dedicatory letter to Prince Philip. In a manner, Professor Lind has given us the spirit of Vesalius, the humanist, the artist, the naturalist.

Dr. Harold E. Myers, head of the agronomy department at Kansas State College, Manhattan, was recently honored by election to the presidency of the Soil Science Society of America.

Dr. L. J. Gier of William Jewell College, Liberty, Missouri, continues his collection of mid-western mosses. During the past October, Dr. and Mrs. Gier collected 400 specimens from eight Missouri counties on a trip to the Lake of the Ozarks.

Mr. George M. Emrich, district traffic manager of the Southwestern Bell Telephone Company, spoke before the Flint Hills Geology Club of Emporia on November 19th on the subject "Kansas Minerals." Mr. Emrich illustrated his lecture with specimens from his own extensive collection.

A report on the extensive work being done at Kansas State College on wind erosion of soils is described in a review by Elbert B. Macy of the State Experiment Station, Manhattan, "Tailor-Made Hurricanes Whip up Erosion Facts" in *Crops and Soils*, August-September, 1949. Reprints of the article may be secured by addressing the Experiment Station.

Publications of the State Geological Survey, University of Kansas, Lawrence, issued since our last announcement, include those listed below. Copies may be secured from the Survey for the price indicated.

Bulletin 77. *Oil and Gas in Eastern Kansas,* with special reference to developments from 1944 to 1948, by J. M. Jewett, 308 pages, 1949. Mailing charge, 25 cents.

Bulletin 78. *Oil and Gas Developments in Kansas During 1948,* by W. A. Ver Wiebe, J. M. Jewett, and Earl K. Nixon, 186 pages, 1949. Mailing charge, 25 cents.

Bulletin 79. *Geology and Ground-Water Resources of a Part of South-Central Kansas* with special reference to the Wichita municipal water supply, by Charles C. Williams and Stanley W. Lohman, 455 pages, 1949. Mailing charge, 25 cents.

Bulletin 80. *Geology and Ground-Water Resources of Pawnee and Edwards Counties, Kansas,* by Thad G. McLaughlin, 189 pages, 1949. Mailing charge, 25 cents.

Bulletin 81. *Geology and Ground-Water Resources of Norton County and Northwestern Phillips County, Kansas,* by John C. Frye and A. R. Leonard, 1949. Mailing charge, 25 cents.

Bulletin 82. *1949 Reports of Studies.*
- Part 1. Chemical and Petrographic Studies of the Fort Hays Chalk in Kansas, by Russell T. Runnels and Ira M. Dubins, 36 pages. Mailing charge, 10 cents.
- Part 2. Preliminary Report on Phosphate-Bearing Shales in Eastern Kansas, by Russell T. Runnels, 12 pages. Mailing charge, 10 cents.
- Part 3. Ceramic Utilization of Northern Kansas Pleistocene Loesses and Fossil Soils, by John C. Frye, Norman Plummer, Russell T. Runnels, and William B. Hladik, 76 pages. Mailing charge, 10 cents.

Bulletin 83. *Divisions of the Pennsylvanian System in Kansas,* by Raymond C. Moore, 204 pages, 1949. Mailing charge, 25 cents.

Bulletin 84. *Ground-Water Conditions in the Smoky Hill Valley in Saline, Dickinson, and Geary Counties, Kansas,* by Bruce F. Latta, 1949. Mailing charge, 25 cents.

No. 8 Cross Section. *Subsurface Geologic Cross Section from Barber County to Saline County, Kansas,* by Wallace Lee, 1949. Mailing charge, 25 cents.

Proper Mixtures of Ellis County Soils for Adobe Construction, and Their Physical Properties.

Part I.

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INTRODUCTION

The word adobe used so commonly in the Southwest originated in Spanish and Moroccan roots which meant "to mix" or "puddle", and later came to be applied to sun-dried brick or to a structure of that material.

In the puddled state the soil grains are brought close together so that there is a mechanical locking between the angular soil particles, and so that the surfaces in contact can be cemented by the clay in the soil. Soil used in making adobe bricks should contain clay or other soil components in sufficient quantities to cause the particles to adhere strongly when dried from a moist and plastic condition, but not to a degree that will cause cracking. Soils which produce bricks with friable and erodable surfaces, because of a lack of binding components or an excessive amount of sand, should not be used.

Sun-dried or Adobe bricks are large mud bricks dried in the sun and then laid up in courses in the wall with mud mortar or regular mortar treated to make it water-proof. These bricks are probably more widely used than all the other methods of earth construction. Their popularity results from two characteristics: (1) The exact amount of shrinkage in the brick is relatively unimportant as long as the unit remains intact; and, (2) the labor requirement is extremely variable, as one man or a dozen may be put to work forming bricks with a minimum of equipment. A special kind of mixer is needed to mix adobe. With an ordinary mixer, the rolling barrel type, the mud has a tendency to form into a ball and roll around inside the barrel. If more water is added the mixture becomes too wet and slumps when the form is removed. A continuous cement mixer, a rotary bread mixer, or a plaster mixer is suitable.

Various sizes and shapes of bricks, to fit any odd places that may occur in construction, can be molded and laid up in the wall along with the standard size bricks. A rectangular brick four inches thick is the common size, though five and six inch thicknesses may be employed if the soil being used is of the proper type and greater attention is given to curing. The forms for shaping the bricks should be constructed from one inch lumber. The inside surfaces of the form should be lined

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with light sheet metal to keep the mud from adhering to the form. Standard size bricks are sometimes made with gang forms, where as high as three or four bricks are formed at one time. The form is removed immediately after the bricks are poured. If the form is not lifted straight up the brick will be deformed. Handles should be placed on the ends of the form to make removing easier. The standard-sized brick four by twelve by eighteen inches is a convenient size to handle. It weighs about fifty pounds; its volume is one half cubic foot and it has a wall face area of one half square foot when laid up in a wall. The computation of the quantity of brick required for any given wall is an easy matter. Smaller sized bricks are sometimes made to facilitate handling or because the soil is such that the larger sizes will crack badly.

The sun-dried brick method of adobe construction has been used successfully since the Civil War period (Long, 3). The use of stabilizers in the adobe bricks makes them water-proof and thus controls the erosion caused by hard driving rains. When a substance absorbs water and the water freezes, part of the material cracks off as the substance dries out. A typical example of this type of erosion can be found on buildings and even more noticeably on building foundations made from native limestone. This type of erosion in adobe construction causes the outside wall coverings, usually stucco, to crack off or pull away from the wall proper. Sometimes adobe bricks not treated with a stabilizer are painted on the outside to protect the bricks from erosion. Painting is not at all successful in localities that are subject to prolonged rain or damp weather or repeated freezing and thawing. Even though the wall erodes it may remain intact for many, many years, but it presents an unsightly appearance. With the use of a stabilizing substance the erosion due almost entirely to the absorption of water, can be completely avoided and the unsightly appearance of the outside of an adobe building does not occur.

Construction of buildings with stabilized soil has been used with much success in several sections of the United States. The purpose of this investigation was to determine whether the soils of Ellis County could be used to form waterproof soil blocks that might be used for construction. In the investigation eight soils found in the county were employed and several stabilizers were added to each in varying amounts to determine if the specific soils could be rendered waterproof. Several types of paint finishes were tested. The work was divided into three main parts: (1) Survey of Ellis County Soils; (2) Selection of soil material with respect to shrinkage; and (3) Treatment of soils with respect to waterproofing.

Collection of Soil Samples

Eight types of soil that appear in Ellis County, Kansas, were tested. Seven of the eight types were found on the Fort Hays Kansas State College Farm. The other sample was found two miles north and one mile east of Hays, Kansas. Each of the samples taken from the Fort Hays Kansas State College Farm was located with the aid of a Soil Map prepared by the United States Soil Conservation Bureau (Bass, 2). Samples were taken from the center of large areas known to be of a specific type. Owing to the poor cultivating properties of the soil north and east of town it was tested for useability in adobe construction.

The top soil was removed in each case to a depth where no grass roots or plant matter was found. This depth varied from ten inches to two feet. A seventy-five pound sample of each type was taken and the samples were stored in bushel baskets. A description of each sample and of the field conditions where they were collected follows:

Boyd clay loam

Even though the top soil was very dry, the subsoil was wet. The color of the sample was dark yellow and a few pieces of limestone were noticed in the sample. The sample was taken from a plowed field on which the last crop was wheat. The field sloped but it was not great enough to cause erosion by water.

Crete silty clay loam

The top soil was very dry but the subsoil was damp. The soil was black, sticky and adhered to the shovel. No limestone particles were noticed and when the sample dried the clods were not very hard. The sample was taken from a flat, plowed field.

Hall silt loam

The top soil was very dry and the subsoil was only damp at twenty inches; the color was very black. The soil crumbled into granules and no limestone particles were found in the sample. The field was under cultivation and was flat.

Hastings silty clay loam

The subsoil was wet and grayish-yellow in color and a few limestone particles were found. The sample was taken from a field that was under cultivation and located near a draw. Erosion by water was noticeable.

Rokeby silty clay loam

The top soil was dry while the subsoil was slightly damp. The soil was light-gray in color and contained no limestone particles. The field where the sample was taken was flat and under cultivation.

Colby silt loam

The subsoil was damp and gray with a slight yellow color and no limestone particles were noticeable. The sample was taken from a pasture of native grass, near a draw.

Colby silt loam (red)

This sample was found north and east of Hays and was taken from a pasture of native grass. The subsoil was damp and redish in color. There was a large quantity of limestone particles present which were extremely small; not pebbles as in the other sample where limestone occurred.

Tripp silt loam

Beneath the grass roots the soil was damp and contained a large amount of very fine sand. The soil sample was taken on the bottom land adjacent to Big Creek.

Determination of Soil Characteristics

One-hundred gram samples were taken from each of the eight seventy-five pound samples and dried in an oven. The oven was constructed from a wooden box approximately three feet long, two and one-half feet wide and two feet deep. One end of the box was used for a door. The box was lined with asbestos one-eighth of an inch thick. The heat was provided by two 300-watt light bulbs mounted in the top of the box. The temperature was kept at 140 degrees F. with a thermostat. The samples were dried for forty-eight hours. They were then pulverized in a mortar using a medium hard rubber pestle.

Ten grams of each of the dried samples were placed in test tubes to which forty grams of distilled water were added. After rubber stoppers were placed in the test tubes they were agitated by a shaking machine for two hours. The test tubes were then placed in an upright position and soil particles allowed to settle. After 24 hours the settling was complete and the liquid was siphoned off and given a hydrogen ion test.

A Beckman model G pH-meter with glass and calomel electrodes was used. The results of the test are shown in Table I.

Table I. Hydrogen Ion Concentration

Soil Type	pH
Boyd clay loam	7.18
Tripp silt loam	7.25
Rokeby silt clay loam	7.15
Colby silt loam	7.67
Crete silty clay	7.31
Hall silt loam	7.31
Hastings silty clay loam	7.34
Colby silt loam (red)	7.47

The residue of each sample was placed in the top sieve of a set of four sieves. The sieves were of the following sizes: 14 mesh,

24 mesh, 66 mesh, and 126 mesh. With the set of sieves in a vertical position each sample was shaken laterally for two hours and the percentage passing each was determined. The result of the analysis are shown in Table II.

Table II. Screen Analysis

Soil Type	Percentage Passing			
	14 mesh	24 mesh	66 mesh	126 mesh
Boyd clay loam	97	75	63	36
Tripp silt loam	95	91	74	51
Rokeby silt clay loam	96	81	70	68
Colby silt loam	99	96	88	76
Crete silty clay	100	91	67	53
Hall silt loam	100	97	79	64
Hastings silty clay loam	96	90	71	67
Cilby silt loam (red)	96	79	56	42

Selection of Soil Material With Respect to Shrinkage

To determine the effect of the addition of sand to the samples a form three inches by five inches by one inch was constructed of one inch lumber and lined with light sheet metal. Samples of each soil were mixed with sufficient water to give a consistency a little less than that of putty. A large piece of sheet rock was used for a pouring surface. The pouring surface was covered with a thin layer of very fine sand to prevent the bricks from sticking to it when dried. The form was dipped in water and placed on the pouring surface. The soil-water mixtures were poured into the form and worked well into the corners. The excess was struck off the top with a straightedge. The form was then lifted from the brick.

A tin trough twelve inches long, eight inches wide and six inches deep was used for a mixing vessel. The soil and water were mixed with a putty knife. The amount of water varied from twenty to forty per cent by weight. After the bricks had dried over night they were set on edge to allow equal curing from both sides.

Sample bricks were poured from pure soil and from mixtures containing 90% soil and 10% sand, 80% soil and 20% sand, 70% soil and 30% sand, and 60% soil and 40% sand. The sand used was standard concrete sand screened through a screen with a one-eighth inch mesh. A description of the sample bricks follows:

Crete silty clay

100% Crete silty clay

The cured bricks were very hard. All three of the samples developed surface cracks. The bricks did not break or crumble. The cracks were large but the samples remained in one piece.

90% Crete silty clay and 10% sand

The cured samples were hard and some warping was noticed. All of the samples broke.

80% Crete silty clay and 20% sand

The cured samples were very hard and some warping was noticed. Two of the three samples broke and the third cracked.

70% Crete silty clay and 30% sand

The cured sample bricks were very hard and none of the bricks broke. All three had medium cracks.

60% Crete silty clay and 40% sand

There were no cracks in the samples which were very hard. Warping was not noticeable and the texture was good.

Hastings silty clay loam

100% Hastings silty clay loam

A few small cracks were found in all of the three bricks. The bricks did not crumble but some warping was noticed.

90% Hastings silty clay loam and 10% sand

The cured samples were very hard with no cracks but some warping occurred.

80% Hastings silty clay loam and 20% sand

Two bricks had no cracks but the third one was cracked. The bricks were not very hard and no warping was noticed.

70% Hastings silty clay loam and 30% sand

There were no cracks and no warping occurred in the three samples. The texture of the bricks was good and they were hard.

60% Hastings silty clay loam and 40% sand

There were no cracks in the three bricks, the texture was sandy and the surface was easily rubbed off, the sample bricks having a tendency to crumble.

Boyd clay loam

100% Boyd clay loam

The cured bricks had large cracks, but were very hard. All of them had at least two cracks extending either along the length of the bricks or across them; never both ways.

90% Boyd clay loam and 10% sand

The cured bricks had large cracks, but were very hard; although they all broke.

80% Boyd clay loam and 20% sand

The bricks showed small cracks and were not very hard, but none of the samples broke. All were badly warped.

70% Boyd clay loam and 30% sand

The cured bricks had no cracks; were very hard. The texture was good and they did not warp.

60% Boyd clay loam and 40% sand

The bricks had no cracks, but were soft and crumbled when rubbed.

Hall silt loam

100% Hall silt loam

The bricks cured very well, no cracks being found in any of the samples. The bricks had a good texture, but were not very hard.

90% Hall silt loam and 20% sand

There were no cracks in the three samples, but the texture was sandy and the bricks had a tendency to crumble. A higher percentage of sand was not tried with Hall silt loam.

Rokeby silty clay loam

100% Rokeby silty clay loam

The bricks cured very well with no cracks or warping. The samples were hard and did not crumble.

90% Rokeby silty clay loam and 10% sand

No cracks were found in the samples, but they were soft and crumbled when handled.

80% Rokeby silty clay loam and 20% sand

The bricks were very soft and crumbled very easily and the texture was very sandy. No cracks were found in the samples.

A higher percentage of sand was not tried with Rokeby silty clay loam

Colby silt loam

100% Colby silt loam

The samples cured very well with no warping. There were no cracks in the samples and the texture was good.

90% Colby silt loam and 10% sand

The sample bricks cured well; no cracks were found and the bricks did not warp.

80% Colby silt loam and 20% sand

There were no cracks in the bricks, but they were soft and crumbled easily.

A higher percentage of sand was not tried with Colby silt loam.

Colby silt loam (red)

100% Colby silt loam (red)

The samples cured very hard, but two broke and the other developed a large crack.

90% Colby silt loam (red) and 10% sand

All three of the samples had medium cracks, but none of them broke.

80% Colby silt loam (red) and 20% sand

The cured bricks were hard, but some small cracks were found.

70% Colby silt loam (red) and 30% sand

The samples cured very hard and no cracks were present.

60% Colby silt loam (red) and 40% sand

No cracks were found in the samples, but they had a tendency to crumble and had a sandy texture.

Tripp silt loam

100% Tripp silt loam

The bricks cured very well and were hard with no cracks.

A higher percentage of sand was not tried with Tripp silt loam.

When the sample bricks were cured they were measured and the percentage of shrinkage from their wet size was determined.

To determine the sand soil mixtures for standard size bricks that would not crack the following work was done.

A form was constructed of one inch lumber and lined with light sheet metal. The inside dimensions were eighteen inches by twelve inches by four inches. This size was chosen because a brick of this size is the largest standard brick. If a brick this size could be made without excess shrinkage, which causes cracking, the smaller sizes and specially-shaped bricks could be made without shrinkage cracks.

A sixty-pound sample of dry soil was dampened with water. After letting the mixture stand until the clods were softened, more water was added and mixed until the mixture was smooth and contained no lumps or clods of dry soil. The amount of water added was such, that the mixture was easily worked into the corners of the form, but not so large an amount that the brick slumped out of shape when the form was immediately removed after the brick was poured. The form was first dipped in water and then placed on a pallet which had been covered with a thin layer of sand to prevent the brick from sticking to it and to allow the brick to move as a whole as it dried. This not only prevented cracking because of sticking to the pallet, but made the brick much easier to remove from the pallet when dry. See Fig. 1.

The mixture was worked into the corners of the form with a trowel and the excess was struck off the top with a straightedge, then the form was removed. (In actual construction work, the upper and lower surfaces, that is the eighteen by twelve faces are sprinkled with sharp gravel to insure a good mortar bond.) The brick was then allowed to dry and cure. If the brick cracked upon drying, it was again mixed with water and more sand was added. The sand had been screened through

an 8-mesh screen. When the mixture was again smooth and contained no lumps of dry soil it was poured as before and allowed to cure. This process was repeated until a mixture was found that when formed into a brick would cure or dry with no cracks.

The sand was added by volume, the first sand-soil mixture was five parts of soil and one part of sand; if that proved unsatisfactory,

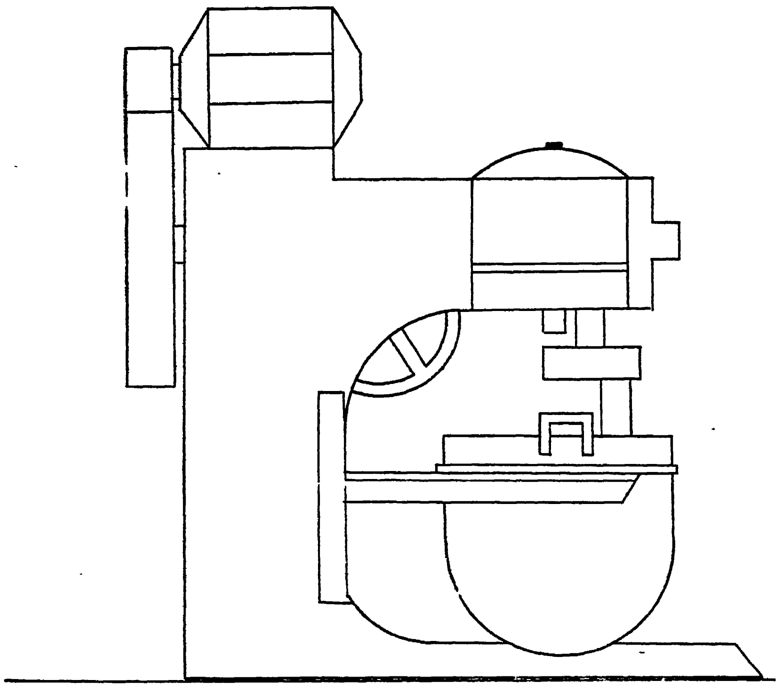

Fig. 1. Discarded bread mixer used to mix 60-pound samples of soil.

five parts of soil to two parts of sand were tried. This process was continued until a sand-soil mixture for each of the eight samples was found that when mixed with water and formed into a brick would dry without cracking. The mixtures are listed in Table III.

Table III. Sand Soil Mixtures Necessary for Bricks That Will Not Crack

Soil Type	Parts of Sand	Parts of Soil
Crete silty clay	3	1
Hastings silty clay loam	7	3
Boyd clay loam	3	1
Hall silt loam	7	3
Colby silt loam	7	3
Colby silt loam (red)	7	3
Rokeby silt clay loam	2	1
Tripp silt loam	0	1

The Effects of Adding Straw

Straw added to soil samples and then molded into sample bricks produced bricks of a quality no better than those containing no straw. The amount of shrinkage was reduced very slightly. The surface of the bricks containing straw was rough and coarse while those containing no straw was smooth. The addition of straw to soils containing the proper mixture of sand and soil apparently had no beneficial effect.

Stabilizers

Substances that are added to the soil-water mixture to produce a water-resistant soil block are called stabilizers. Six stabilizers were tested:

asphalt
road oil
reduced crude oil
residium*
colas G-104
bitudobe

The asphalt was of the type used as a roof coating. At room temperature is it a solid. The asphalt was heated until it was a liquid and kerosene was added. When the mixture cooled and the kerosene had evaporated the asphalt was in a very fine granular form. Asphalt in this form was tested.

The road oil was the type used in the surfacing of highways and was obtained from the Kansas State Highway Commission. It is a heavy black substance and is a liquid at room temperature.

Reduced crude oil was obtained at the Co-op Refinery located in Phillipsburg, Kansas. It is black in color, a liquid at room temperature and very heavy.

The residium was also obtained at the Co-op Refinery and is a heavy black liquid at room temperature.

Colas G-104 is a product manufactured by the Shell Oil Company for surfacing highways. It is dark brown in color and has the consistency of water at room temperature.

The bitudobe was purchased from the American Bitumuls Company. It is dark brown in color and has the consistency of water. Bitudobe is a product manufactured especially for stabilizing soil blocks.

Three of the stabilizers were discarded after preliminary tests which consisted of the following: Sample bricks three inches by five inches by one inch were poured. All of these samples were made from Tripp silt loam. Sample bricks were made containing 10% by weight of each of the six stabilizers. All of the bricks when cured were hard.

* See Riegels "Indus. Chem.," 3rd ed. (Reinhold Pub.), p. 404.

The samples were dipped in water and removed. Drops of water stood on the surfaces of all the sample bricks except the one containing asphalt. The sample containing the asphalt absorbed the water so asphalt was discarded.

The remaining samples were then placed on edge on a wet sponge. At the end of 12 hours the sample bricks were inspected. The sample bricks containing road oil and reduced crude oil developed very small cracks along the surface that was in contact with the sponge. When that surface was touched with the finger it crumbled away. Reduced crude oil and the road oil were discarded leaving residium, colas and bitudobe for more extensive tests.

Water Absorption Tests

Sample bricks, one and one-half inch cubes, were made to be used for the water absorption tests. The sand soil mixtures as given in Table III were used. Three different amounts of each of the three stabilizers were used:

1. One pound of stabilizer to fifty pounds of sand and soil.
2. Two pounds of stabilizer to fifty pounds of sand and soil.
3. Three pounds of stabilizer to fifty pounds of sand and soil.

Proper amounts of sand and soil were mixed dry. Then water was added and lastly the correct amount of stabilizer for the specific sample was added. The mixture was worked until its color was uniform. A form, three inches by five inches by one inch, was dipped in water and placed on a sand-covered level surface. The mixture was poured in, worked well into the corners and the top struck off smooth. The form was then removed. After the sample brick had stood for an hour a one-inch cube was cut from the corner with a knife which had first been dipped in water. The cubes were allowed to stand for 24 hours. At the end of that time the rough edges of the cubes were squared with

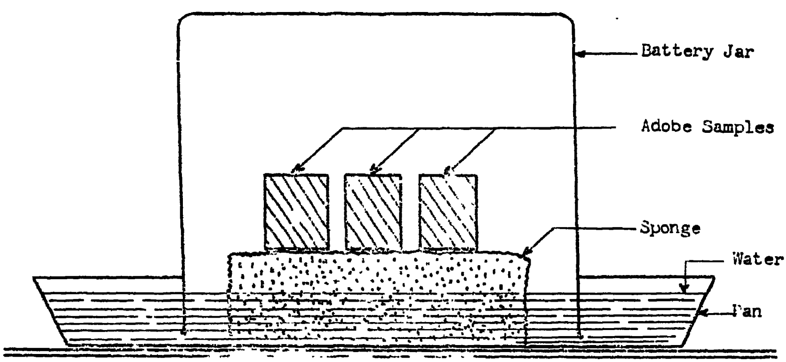

Fig. 2. Moist cabinet for absorption tests.

a knife. This was easily done because the sample bricks were not yet thoroughly dry. They were just dry enough to handle. They were allowed to cure for a week. At the end of that time they were placed in an oven kept at 140° F. until they attained a constant weight, which was recorded as the dry weight. The samples were placed upon a rectangular sponge one inch thick. The sponge with the sample bricks was placed in a pan three-fourths of an inch deep. A battery-jar was placed upside down over the sponge and the pan was filled with water. The lip of the battery-jar was kept under the surface of the water at all times. The jar and pan thus formed a moist cabinet as shown in Fig. 2. The battery-jar did not fit the bottom of the pan so tightly as to prevent the water from seeping under the jar as it was being absorbed by the sponge.

After seven days the sample bricks were weighed and the increase in weight from absorbed water determined. The results are given in Table IV.

Table IV. The Percentage Increase in Weight in Absorption Tests

Soil Type	Stabilizer	1 lb. to 50 lb.	2 lb. to 50 lb.	3 lb. to 50 lb.
Boyd clay loam	Bitudobe	14.70	13.50	5.82
	Colas	4.95	3.32	2.38
	Residium	3.38	3.24	2.39
Tripp silt loam	Bitudobe	24.00	11.40	3.97
	Colas	6.95	5.65	5.25
	Residium	3.11	2.28	1.70
Rokeby silt clay loam	Bitudobe	6.80	2.20	1.97
	Colas	3.39	2.20	1.55
	Residium	1.98	1.90	1.54
Colby silt loam	Bitudobe	13.40	8.21	3.92
	Colas	4.38	2.51	2.15
	Residium	4.08	2.40	2.21
Crete silty clay	Bitudobe	9.90	6.23	3.80
	Colas	4.45	3.35	2.80
	Residium	3.28	2.97	2.26
Hall silt loam	Bitudobe	10.50	4.05	2.58
	Colas	3.99	3.35	3.23
	Residium	1.83	1.22	1.05
Hastings silty clay loam	Bitudobe	9.30	6.41	3.72
	Colas	4.60	3.88	2.08
	Residium	2.84	1.92	1.42
Colby silt loam (red)	Bitudobe	10.30	10.20	2.94
	Colas	9.50	5.60	1.83
	Residium	5.00	3.29	1.28

Erosion Tests

A form four by three by one inch was constructed and lined with light sheet metal. The bricks were molded on a piece of sheet-rock sprinkled with fine sand. The mixture of sand and soil given in Table III was first mixed in a dry state. Water was then added until the mixture had the correct consistency. Lastly the stabilizers were added and the components mixed until the batch had a uniform color. The color was produced by the stabilizers, colas and bitudobe yielding brown, and residium giving black.

Three amounts of stabilizers were tried as follows:

1. One pound of stabilizer to fifty pounds of sand and soil.
2. Two pounds of stabilizer to fifty pounds of sand and soil.

3. Three pounds of stabilizer to fifty pounds of sand and oil.

Thus for each type of soil nine separate mixtures were tested, that is, three of each stabilizer.

The sample bricks were poured on the sand-covered surface and the mold removed immediately. After 48 hours the bricks were placed on edge to hasten the curing. Two bricks of each mixture were made, 144 bricks in all.

After the sample bricks had cured for approximately a week they were placed in an oven and kept at 140° F. until each brick had a

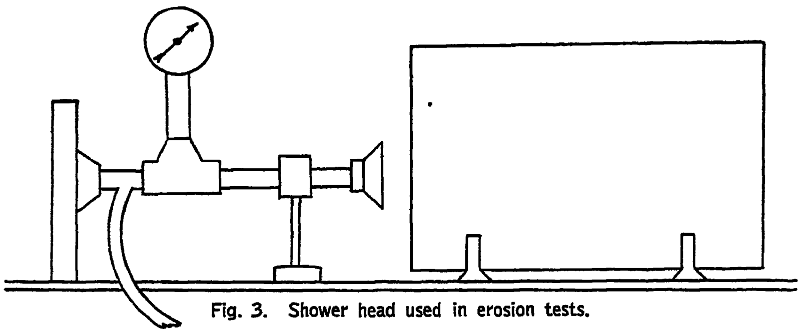

Fig. 3. Shower head used in erosion tests.

constant weight, assuring that the bricks were completely dry. The bricks were then piled in a dry place until given the test for erosion.

The erosion tests consisted of the following: dry sample bricks were blaced on edge and sprayed with water from a 2 inch shower

Table V. Table Showing the Result of Erosion Test
(One pound of stabilizer to fifty pounds of sand-soil mixture)

Soil Type	Stabilizer	Time	Maximum Depth of Erosion	Brick Condition	Extent of Erosion
Boyd clay loam	Bitudobe	3 m.*	¾ inch	very soft	very great
	Colas	5 m.	¾ inch	very soft	very great
	Residium	10 m.	½ inch	soft	medium
Tripp silt loam	Bitudobe	2 hr.**	¾ inch	soft	very great
	Colas	2 hr.	¼ inch	slightly soft	slight
	Residium	2 hr.	1/32 inch	hard	very slight
Rokeby silt clay loam	Bitudobe	35 m.	⅜ inch	soft	medium
	Colas	2 hr.	⅛ inch	hard	slight
	Residium	2 hr.	none	hard	none
Colby silt loam	Bitudobe	25 m.	¾ inch	very soft	very great
	Colas	2 hr.	⅜ inch	soft	medium
	Residium	2 hr.	⅜ inch	soft	medium
Crete silty clay	Bitudobe	3 m.	½ inch	very soft	great
	Colas	5 m.	¾ inch	soft	great
	Residium	34 m.	¾ inch	soft	great
Hall silt loam	Bitudobe	30 m.	¾ inch	soft	very great
	Colas	30 m.	7/16 inch	soft	great
	Residium	2 hr.	¼ inch	hard	slight
Hastings silty clay loam	Bitudobe	15 m.	⅝ inch	soft	medium
	Colas	15 m.	5/16 inch	soft	medium
	Residium	70 m.	5/16 inch	soft	medium
Colby silty loam (red)	Bitudobe	17 m.	¾ inch	soft	very great
	Colas	15 m.	½ inch	soft	great
	Residium	25 m.	⅝ inch	soft	medium

* minute
** hour

head. The pressure of the water was 10 pounds. The distance of the shower head from the bricks was seven inches. The time for spraying varied from three minutes to a maximum time of two hours. (The apparatus is shown in Figure 3.) If a brick became eroded within the time limit, the time was noted and the brick removed from the spray. A number of samples showed no erosion after two hours of continuous spraying. The results of the tests are given in Table V.

Table V. Table Showing the Result of Erosion Test (Continued)
(Two pounds of stabilizer to fifty pounds of sand-soil mixture)

Soil Type	Stabilizer	Time	Maximum Depth of Erosion	Brick Condition	Extent of Erosion
	Bitudobe	5 m.	½ inch	soft	great
Boyd clay loam	Colas	30 m.	¾ inch	very soft	very great
	Residium	30 m.	½ inch	soft	medium
	Bitudobe	2 hr.	¼ inch	slightly soft	medium
Tripp silt loam	Colas	2 hr.	⅛ inch	hard	very slight
	Residium	2 hr.	none	very hard	none
	Bitudobe	2 hr.	none	very hard	none
Rokeby silt clay loam	Colas	2 hr.	none	very hard	none
	Residium	2 hr.	none	very hard	none
	Bitudobe	1 hr.	¼ inch	slightly soft	medium
Colby silt loam	Colas	2 hr.	1/16 inch	hard	very slight
	Residium	2 hr.	none	hard	none
	Bitudobe	16 m.	⅜ inch	soft	medium
Crete silty clay	Colas	1 hr.	⅜ inch	soft	medium
	Residium	1½ hr.	¼ inch	soft	medium
	Bitudobe	2 hr.	⅜ inch	soft	medium
Hall silt loam	Colas	2 hr.	¼ inch	hard	slight
	Residium	2 hr.	none	hard	none
	Bitudobe	1¼ hr.	7/16 inch	soft	medium
Hastings silty clay loam	Colas	2 hr.	⅛ inch	hard	slight
	Residium	2 hr.	⅛ inch	hard	slight
	Bitudobe	17 m.	⅜ inch	soft	medium
Colby silty loam (red)	Colas	2 hr.	½ inch	soft	great
	Residium	2 hr.	⅛ inch	slightly soft	slight

Table V. Table Showing the Result of Erosion Test (Continued)
(Three pounds of stabilizer to fifty pounds of sand-soil mixture)

Soil Type	Stabilizer	Time	Maximum Depth of Erosion	Brick Condition	Extent of Erosion
	Bitudobe	5 m.	⅜ inch	slightly soft	medium
Boyd clay loam	Colas	1 hr.	½ inch	slightly soft	medium
	Residium	2 hr.	⅜ inch	slightly soft	medium
	Bitudobe	2 hr.	none	very hard	none
Tripp silt loam	Colas	2 hr.	1/16	very hard	very very slight
	Residium	2 hr.	none	very hard	none
	Bitudobe	2 hr.	none	very hard	none
Rokeby silt clay loam	Colas	2 hr.	none	very hard	none
	Residium	2 hr.	none	very hard	none
	Bitudobe	2 hr.	none	hard	very very slight
Colby silt loam	Colas	2 hr.	none	very hard	none
	Residium	2 hr.	none	very hard	none
	Bitudobe	16 m.	¼ inch	soft	medium
Crete silty clay	Colas	1 hr.	3/16 inch	hard	slight
	Residium	2 hr.	none	hard	very slight
	Bitudobe	2 hr.	none	hard	very slight
Hall silt loam	Colas	2 hr.	none	very hard	none
	Residium	2 hr.	none	very hard	none
	Bitudobe	1¼ hr.	⅛ inch	hard	slight
Hastings silty clay loam	Colas	2 hr.	none	hard	very slight
	Residium	2 hr.	none	very hard	none
	Bitudobe	2 hr.	¼ inch	soft	medium
Colby silty loam (red)	Colas	2 hr.	1/16 inch	hard	very slight
	Residium	2 hr.	none	very hard	none

Adaptability To Paint

A set of bricks the same size and having the same proportions of stabilizer as those used in the erosion tests was poured. The bricks were dried to constant weight. One-third of each sample brick was painted with aluminum paint, one-third was not painted and the other one-third was painted with asphalt base aluminum paint. The paint was allowed to dry for 48 hours. Then one-half of each of the three areas was given a coat of outside white house paint. After 48 hours a second coat of the white paint was given these surfaces. The paint was then allowed to dry for one week.

The aluminum paint used was Aluminum Du Pont Duco, made by E. I. Du Pont De Nemours and Co., Inc., Wilmington, Delaware. The asphalt-base aluminum used was Mayfair Asphalt Aluminum, Paint No. 2971 made by the Waggener Paint Company, Kansas City, Missouri. The outside house paint used was Pittsburgh Sun-Proof House Paint, 1-54v titanic outside white.

At the end of the drying period the paint was hard. All three of the strips given the two coats of white house paint were equally white. The bricks were laid flat and sprinkled with water. The amount of water was great enough to allow water to stand on the surface of the bricks. The temperature of the bricks was 70° F. The samples were then placed out-of-doors on a table, being careful not to spill the water from the surface of the bricks. Snow was falling and the temperature was 20° F. The samples were left out-of-doors for 48 hours. The lowest temperature during that period was —23° F. Owing to the location of the table, the sun of the following day, was warm enough to melt the snow that had fallen on the samples. That night the temperature dropped to 15°F. freezing the water and bricks again. The following morning the samples were moved indoors where the temperature was 80° F. The samples experienced a 103° change in temperature and were frozen twice. Upon careful examination no deterioration of exposed brick surface or of the painted surfaces was found.

The stabilizers did not show through the two coats of white paint on the bare brick, nor did they show after a period of 30 days. Using the Du Pont Aluminum or the Mayfair Asphalt Base Aluminum as a prime coat, made covering with white paint much easier. One coat of aluminum completely covered the black color of the samples made from soils stabilized with residium.

Conclusion

The soils of Ellis County are in general suitable for use in making abode bricks. All but one of the eight samples had to be blended with

sand to prevent cracking. The amount of sand that had to be added could not be determined from the simple screen analysis nor from the hydrogen ion concentration. Pouring sample bricks with varying percentages of sand is the most dependable method of finding the admixture of sand necessary.

The requirements of the Federal Housing Administration for adobe brick construction is that the bricks be rendered water-resistant (Long, 3).

For a brick to be considered water-resistant the American Bitumuls Company requires that it absorb not more than 2.5% moisture by weight when exposed to a wet surface for seven days and should not be appreciably pitted or eroded in two hours of spraying with a fine spray (American Bitumuls Co., 1). It appears that all of the samples tested could be made to meet those requirements if a sufficient amount of stabilizer is used. The amount of residium needed to meet these requirements was less than that required of colas or bitudobe. In most cases less colas was required than bitudobe.

A prime coat of asphalt aluminum paint forms a very fine base for painting. The asphalt paint is also a water-proofing substance. The paint was applied with a brush. A better and more complete covering of the rough surface could have been made by spraying the paint on the surface. The tests given the painted surfaces were limited. To reproduce the climatic conditions of Ellis County for a span of five years was beyond the scope of the experimental work. From the tests given it appears that the surfaces will "take" paint and that the paint will retain its original color.

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The Southern Races of Eumeces Septentrionalis (Baird)*

HOBART M. SMITH and JAMES A. SLATER

Observation in the field of the existence of a rather striking difference in pattern and color between eastern and western specimens of *Eumeces septentrionalis obtusirostris* Bocourt in Texas has led to an examination of all material available that has been referred to that subspecies.

We have concluded that two rather poorly defined races are involved, differing not only as observed in the field but also in two features of scutellation.

Our study has been based upon a total of 138 specimens, more than twice as many as Taylor (1936) had available. These have been made available through the courtesy of Mr. Bryce C. Brown, Dr. Doris Cochran, Mr. Harold A. Dundee, Dr. Howard K. Gloyd, Dr. Norman Hartweg, Mr. J. E. Johnson, Mr. A. J. Kirn, Mr. Arthur Loveridge, Mr. M. Graham Netting, Dr. A. I. Ortenburger, Mr. Clifford H. Pope, Mr. Floyd Potter, Mr. L. W. Ramsey, Mr. K. P. Schmidt and Dr. Edward H. Taylor. Abbreviations for museum or personal collections are: AJK, Alvin J. Kirn; B.U., Baylor University, Strecker Museum; CAS, Chicago Academy of Sciences; CM, Carnegie Museum; CNHM, Chicago Natural History Museum; EHT, Edward H. Taylor; FP, Floyd Potter; HAD, Harold A. Dundee; LWR, Leo W. Ramsey; MCZ, Museum of Comparative Zoology; MZUM, Museum of Zoology, University of Michigan; UIMNH, University of Illinois Museum of Natural History; UKMNH, University of Kansas Museum of Natural History; UOMZ, University of Oklahoma Museum of Zoology; USNM, United States National Museum. We have in addition received notes on the natural history of the species from Mr. Harold A. Dundee, Mr. J. E. Johnson, Jr., Mr. A. J. Kirn, and Mr. L. W. Ramsey, to all of whom we are especially grateful.

Eumeces septentrionalis pallidus subsp. nov.

Holotype. UIMNH No. 1961, Palo Pinto, Palo Pinto Co., Texas, collected May 1, 1946, by Mr. Philip Harter. *Paratypes.* UIMNH Nos. 1962-3, BCB Nos. 4138, 4197, FP Nos. 90, 330, 331, all topotypes; UIMNH No. 1965, AJK 2 specimens, Ottine, Gonzales Co., Texas; UIMNH No. 1964, AJK 2 specimens, CM No. 8464, UKMNH Nos. 7745, 7765, 12744-5, 15562, EHT Nos. A838, A839, A1435, BU Nos. 5112, 5113, 7 miles southeast of Lytle; AJK 1 specimen, Coyote,

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Atascosa Co., Texas; Somerset, Bexar Co., Texas; USMN No. 58337, Paisano, Brewster Co., Texas. *Hypoparatypes.* UIMNH Nos. 1946-59, topotypes (juveniles); UIMNH No. 1960, 7 miles southeast of Lytle, Atascosa Co., Texas (atypical pattern); AJK No. 1912, Somerset, Bexar Co., Texas (juvenile); AJK No. 1915, 3 miles south of Lytle, Atascosa Co., Texas (juvenile); and AJK 1 specimen, northwestern Atascosa Co., Texas (juvenile). We are aware of no records in the literature for other localities.

Diagnosis. Similar to *Eumeces septentrionalis obtusirostris,* having two postmentals, postnasal absent, median row of subcaudals not appreci-

Fig. 1. Specimens showing characteristic patterns of the races of Eumeces septentrionalis. Left: E. s. obtusirotris, typical; UIMNH No. 1942, 13 miles east of Byran, Brazos Co., Texas; Aug. 14, 1946; Gus A. Engeling. Left Middle: E. s. obtusirostris, northwestern variant; UOMZ No. 13500, Pottawatomie Co., Oklahoma. Right Middle E. s. septentrionalis, typical; FMNH No. 13076, Onaga, Pottawatomie Co., Kansas; F. A. Crevecoeur. Right: E. s. pallidus, typical; UIMNH No. 1965, Ottine, Gonzalez Co., Texas; March 31, 1937; A. J. Kirn. Photograph by Ray J. Hamm, University of Illinois Staff Photographer.

ably wider than adjacent scales, and a dorsolateral light line following usually the fourth row of scales (sometimes involving also the 5th or 3rd). Differing from *E. s. obtusirostris* in the absence or poor development of the dark line mesad of the dorsolateral light line (81%); median stripe usually absent (95%); prefrontals often (72%) broadly in contact; lateral scale rows usually parallel (82%); lateral light stripe often absent; ground color light olive; head often reddish in adults. Dorsals 53-58, average 55.3; scale rows about body 26-28, average 27.5; lamellae under longest toe 12-15, average 13.5.

Description of holotype. Rostral large, the part visible from above at least as large as the frontonasal; supranasals rectangular, their common median suture nearly one-half length of frontonasal and subequal to that of prefrontals; frontonasal relatively large, in contact with anterior loreals; prefrontals large, their common median suture one-half their maximum length, in contact laterally with the anterior and posterior loreals and the first supraocular, their length entering the distance from their cephalic margin to the tip of the snout one and one third times; frontal bordered laterally by the first, second and, narrowly, the third supraoculars, its length exceeding its distance from the tip of snout; frontoparietals large, broadly in contact medially, touching the frontal, third and fourth supraoculars, parietals and interparietal; supraoculars four, second much the largest; interparietal not enclosed by the parietals which are very large and broad, and truncate on their posterior margins; one pair of large nuchals.

Nasal large, undivided, nearly equalling supranasal in area, becoming reduced in elevation from anterior to posterior extremities; postnasal absent; two loreals, anterior in contact below with first and second upper labials; posterior loreal more than twice length of anterior, narrowing in height caudad, in contact with the second, third and fourth upper labials, preocular, first presubocular, first supraocular, and first superciliary; six superciliaries, first much the largest, decreasing in size from one to six, the last nearly equal to the third in size; two presuboculars; four postsuboculars, all small, decreasing posteriorly in size; two postoculars; primary temporal of moderate size, rectangular, contacting second and third postsuboculars, sixth and seventh upper labials and upper and lower secondary temporals; upper secondary temporal largest; one tertiary temporal, not in contact with nuchals; seven upper labials, posterior the largest, anterior loreal forming a notch on dorsal margin of first and second labials, fifth (subocular) labial

longer than high; postlabials two, the upper more than twice height of lower.

Seven lower labials, the sixth elongate and rounded on caudal margin; mental large, wider at lip than rostral; two postmentals, the anterior small and in contact with the posterior by a straight transverse suture, the posterior much larger and strongly produced caudad mesally; three-four pairs of chinshields and a narrow elongate postgenial; scale bordering anterior inner edge of latter longer than wide; eyes of moderate size, lower lid with five enlarged scales separated from the upper labials by two full rows and a partial third row of granular scales.

Body scales in parallel rows except on sides, where they are slightly oblique on both sides anterior to the middle of the body, and on one side posterior to the middle (in the latter case, one scale row is dropped 15 scales in front of the level of the rear of the thighs); twenty-eight scale rows about middle of body; fifty-seven dorsal scales from parietals to posterior margin of thighs; median row of ventral scales on tail not perceptibly widened; two enlarged preanals; limbs small, separated by not less than ten rows of scales when adpressed; lamellar number of fore digits 5-8-10-10-5, of hind digits 5-8-12-15-8; scales under palms imbricated, overlapping and irregular, claws small but prominent.

Color and pattern (in alcohol): Ground color above rich brown; no median line; two pairs of light whitish longitudinal stripes; dorsolateral stripe originating along the lateral edges of the supraoculars and running caudad through the center of the fourth row of scales to terminate on the basal quarter of the tail, poorly defined on the posterior one-fourth of the body; lateral light stripe originating above the ear, passing caudad above the articulation of the fore limbs and following the seventh scale row most of its length, terminating caudally on the basal portion of the tail; dorsolateral and lateral light stripes thus separated on the body by the lower one-fourth of the fourth row of scales, all of the fifth and sixth, and the upper one-third of the seventh, this intervening area somewhat darker brown than the ground color and flecked with black; lateral area ventrad of the lateral light stripe and venter dull bluish-gray; upper labials, lower jaw and throat caudad to the level of the ear openings a very pale cream; upper surface of limbs brown, lower surfaces light as throat; head and body flecked with greenish iridescence.

In life the upper and lower labials, and sides of neck posteriorly nearly to the front legs, are orange.

Measurements are as follows: Length snout to vent, 68 mm.;

length snout to foreleg, 20 mm.; width of head, 8.4 mm.; length of head, 11 mm.; length of foreleg, 14 mm.; length of hind leg, 18 mm.; length of longest toe, 7 mm.

Variation. Data are available on the features of scutellation in twenty-eight specimens varying in length from 24 mm. to 71.5 mm. snout to vent. The dorsals from interparietal to base of tail vary from 53 to 59, average 55.4 (53, one; 54, seven; 55, six; 56, six; 57, six; 59, one). The scale rows vary from 26 to 30, generally 28, average 27.7 (26, five; 27, one; 28, twenty-one; 30, one). The lateral scale rows are perfectly parallel in the groin in 23 (82%), oblique in five (18%). The lamellae on the 4th toe vary from 12 to 15, generally are 14, average 13.5 (12, seven; 13, three; 14, fourteen; 15, four). The prefrontals are broadly in contact in 8 (28%) separated or narrowly in contact in 13 (72%). The frontonasals are in contact with the anterior loreal on both sides in 20, on neither side in 5, on one side only in 3. The second supraocular is in contact with the frontal on one side in 5, on neither side in 23. In one specimen there is only 1 postmental; 2 occur in 27.

The dorsolateral light stripe occupies only the 4th scale row in 21 specimens; it occupies rows 3 and 4 in 6 specimens, and rows 4 and 5 in one. Paravertebral dark lines, bordering a vertebral light line, are clearly visible in one specimen (KU No. 12745, from Atascosa Co., Texas), faint in one (USNM No. 58337, from Brewster Co., Texas), absent in the remainder; a faint median light line is visible in two other specimens (from Atascosa Co.), but the dark borders are absent. The dark line bordering the dorsolateral light line medially is well developed in 4, narrow but clear in 4, faint in 2, absent in the remainder.

Fourteen juveniles (UIMNH Nos. 1946-59) hatched from the eggs laid by 2 females from Palo Pinto, Texas (UIMNH Nos. 1961, 1963) are available. No data from these were included in the preceding summaries. Originally 16 eggs were in the two clutches, laid May 11, 1946. The eggs hatched June 8, 1946. At hatching the average snout-vent length was 24 mm., and the average tail length was 28 mm. All were preserved a month or two after hatching. After two years in preservative 13 of the young measured 24-25 mm., average 24.5 mm.; tail length 29-34, average 31.3, average 31.3 (seven specimens); dorsals 53-58, average 56; scales about body 26-28, average 27.7; scales under largest toe 11-14, average 12.2. The prefrontals are in contact in seven specimens and not in contact in six. The second

supraocular is in contact with the frontoparietals, at least on one side, in seven specimens and not in contact on either side in seven.

In life, the newly hatched young were black above, except for (1) light spots on the head, (2) a fine discontinuous dorsolateral light line, and (3) a bluish tail; light areas on sides and top of head brick red; dorsolateral light line spotted, not reaching groin; no median line; lateral light line reaching two-fifths of distance to groin. Larger juvenile specimens have brighter red on the head and brighter blue tails.

Mr. A. J. Kirn took a young specimen 55 mm. in length, snout to vent, at Somerset, Atascosa County, Texas. His description from life follows: "Color above from posterior part of head back, including all of body and one-third of tail, dark colored; remainder of upper part of tail blue. Fore part of head rusty, also on side from ear forward; dark from eye back on side of head. A very narrow white line from in front of eye to ear, then becoming dotted (instead of solid) to well back on body. A suspicion of a dotted median line on most of body, from head back; a faint dotted line (dorsolateral) between median and lateral spotted lines. Considerably rusty on entire top of head, fading out on neck. Legs like back. Blue of tail fading out at posterior extremity of adpressed hind legs. Below: under part of head and throat white; fore part of body grayish, remainder and one-third of tail dark. Posterior two-thirds of tail blue." A specimen of similar size collected by Mr. Kirn at Lytle, Atascosa County, Texas, differed from the above description in lacking the median longitudinal line of spots.

Eumeces septentrionalis obtusirostris Bocourt

Eumeces obtusirostris Bocourt, Mission Scientifique au Mexique . . . , Etudes sur les reptiles, livr. 6, 1879, p. 423, pl. 22D, figs. 1, 1a, 1b, and livr. 7, 1881, pp. 441-443 (type locality "Texas," here restricted to Dallas, Texas).

Eumeces pachyurus Cope, Bull. U. S. Nat. Bus. No. 17, 1880, pp. 19-20, 39 (type locality Dallas, Texas).

Specimens Examined. KANSAS. Comanche Co.: Schwartz Canyon (UKMNH Nos. 20330-1). OKLAHOMA. *Caddo Co.*: Old Ft. Cobb (USNM No. 11837(2), 11840). *Carter Co.*: just S. of Murray Co. line in Arbuckle Mts., on U. S. 77 (HAD 2172); 5 miles west of Ardmore (HAD 1), 6 miles south of Ardmore (HAD #1). *Cleveland Co.* (UOMZ 466): 2 miles south of Norman (HAD 1). *Garvin Co.* (UOMZ Nos. 10416-8); Mayesville (UOMZ Nos. 10130-1). *Kay Co.* (UOMZ 9729, 9742-5, MZUM 77578). *Kiowa Co.*: Cooperton (UOMZ No. 25598). *Love Co.* (UOMZ No. 8893); 4 miles east of Oswalt

(HAD 1, UOMZ No. 24969). *Okmulgee Co.* (UOMZ No. 12054, 12310). *Osage Co.*: Osage Hills State Park between Powhuska and Bartlesville (HAD 1). *Pottowatomie Co.* (UOMZ Nos. 13500, 24868): Tecumseh (HAD No. 190). *Seminole Co.* (UOMZ No. 10504). *Stephens Co.*: Lake Duncan (HAD 1). *Tulsa Co.* (UOMZ No. 1576, CNHM No. 8345, MZUM Nos. 68454 (4), MCZ No. 46697): 6 miles W. of Tulsa at Lost City Quarry (HAD 2072): TEXAS. *Brazos Co.*: vicinity of College Station and Bryan (UIMNH Nos. 1939-1943, BCB No. 1970, LWR No. 121-c). *Cook Co.* (USNM No. 15543). *Dallas Co.*: Dallas (BU Nos. 5187-8). *Leon Co.*: Normangee (UIMNH No. 1945). *Limestone Co.*: Ft. Parker State Park, 6 miles north of Grosbeck (JEJ 2 specimens). *McLennan Co.*: vicinity of Waco (UIMNH Nos. 1930-8, 1944, BCB No. 2461, CNHM No. 11008, UKMNH Nos. 7799, 7801-2, 13157-9, BU Nos. 0690, 0806, 2814, 3150, 3740-1, 4290-2 4758, 5110-1, 6602(2), 6607(2), 6616); Ada (CNHM No. 44227). *Parker Co.*: 4 miles east of Mineral Wells (UKMNH No. 8992). *Wharton Co.*: Chesterville (BCB Nos. 2832-3). *Wilson Co.*: 3 miles west of Stockdale (CAS No. 11525).

Literature Records. We are aware of but one other locality record we have not checked by examining specimens; it is for Norwich, Kingman Co., Kansas (Taylor, 1936:410).

Diagnosis. Related to *Eumeces s. septentrionalis* (Baird), in having two postmentals, no postnasal, median row of subcaudals not appreciably wider than adjacent scales, and a dorsolateral light line following usually the 4th row of scales only (sometimes involving also the 5th or 3rd). Differing from *E. s. pallidus* in the usual presence (72%) of a dark-bordered median light line; usually (82%) a well-developed median dark border on dorsolateral light line; lateral scale rows usually (75%) oblique at least slightly; prefrontals less frequently in broad contact (39%). Dorsals 53 to 59, average 55.6; scale rows about body 26 to 30, average 27.9; lamellae under longest toe 11 to 17, average 13.6.

Variation. The largest specimen seen measured 74.5 mm. snout to vent (OUMZ No. 466, Cleveland Co., Okla). The dorsals from interparietal to base of tail vary from 53 to 59, average 55.6 (53, three; 54, twelve; 55, twelve; 56, sixteen; 57, eight; 58, six; 59, one); the scale rows vary from 26 to 30, average 27.9, usually 28 (26, six; 27, two; 28, forty-seven; 29, two; 30, two); lateral scale rows parallel in 15, oblique in 45; lamellae on 4th toe 11 to 17, average 13.6 (11, one; 12, eleven; 13, fourteen; 14, nineteen; 15, nine; 16, three; 17, one); prefrontals broadly in contact in 25, not in 16; frontonasal in contact with anterior loreal on both sides in 37, on one side in 9, on

neither side in 12; second supraocular in contact with frontal on one side in 3, on neither side in remainder; postmentals partly (½ and 4/5) fused in two.

The dorsolateral light line is restricted to the 4th scale row in 44 specimens, involves the 3rd also in 7, and the 5th also in 7; paravertebral dark lines, bordering a median light line, are well developed in 41, faint in 7, absent in 8; the dark line bordering the dorsolateral light line medially is absent or weak in 10, well developed in 46.

One litter of 7 specimens (Nos. 1930-3, 1935-8) was hatched from a clutch of 8 eggs laid by a specimen (UIMNH No. 1934) from Waco, Texas. Data from these have not been included in the preceding summaries. Snout-vent length, in newly-hatched specimens, 24-25 mm. with an average of 24.6 mm.; length of tail 25-31 mm., average 29 mm.; dorsals 54-57, average 55.4; scale rows about body 26-28. The second supraocular is not in contact with the frontoparietal in any of the seven specimens; prefrontals in contact mesally in three specimens, not in five. A light median line is usually discernible. The juvenile coloration has been described by Strecker (1910:119).

Comparisons. E. s. obtusirostris differs from *E. s. pallidus* to a taxonomically significant degree in each of 3 characters; at least one other statistically significant difference of less than taxonomic significance is discernible. These four differences may be summarized as follows (the taxonomically significant are listed first):

	obtusirostris	*pallidus*
upper dorsolateral dark line well defined	82%	19%
paravertebral dark lines well developed	72%	5%
lateral scale rows oblique posteriorly	75%	18%
prefrontals broadly in contact	61%	28%

The hatchlings of the two races are very much alike, but those of *E. s. pallidus* appear to lack evidence of a median light line, while those of *E. s. obtusirostris* possess a series of light spots which represent that line. Unfortunately preserved material does not permit proper evaluation of this feature.

Possibly an average difference in tail length exists; the hatchlings of *E. s. pallidus* have longer tails than those of *E. s. obtusirostris,* and the adults of the two races with complete tails show an average difference; paucity of specimens with perfect tails renders unreliable any comparison of this feature on the basis of the present series.

The most conspicuous differences—in fact the ones that led to the present study—are in pattern and color. The pallid ground color and reduction of stripes to a single dark lateral line on each side, in *E. s. pallidus,* are immediately obvious and distinctive. These features have been used as the criteria for allocation of otherwise intermediate populations with one race or the other.

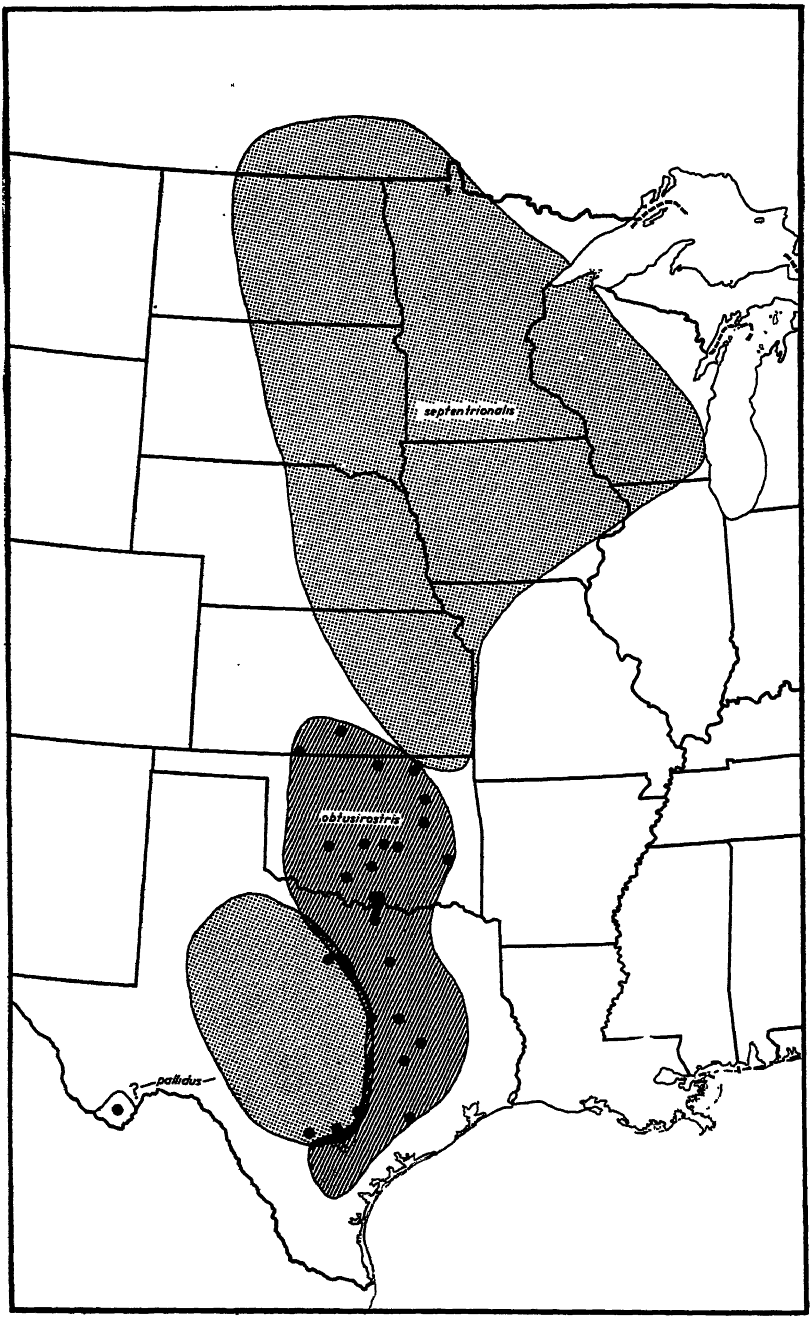

Fig. 2. Distribution of the races of Eumeces septentrionalis. Specific localities are indicated by solid dots; the general range is approximated by shading.

Intergrading populations occur at various localities where the ranges of the races approximate each other; in Gonzales County there is a more nearly equal representation of the two types than elsewhere. Specimens more or less typical of *E. s. obtusirostris* are also available from Atascosa County where by far the greater number are typical *E. s. pallidus;* likewise some from McLennan County resemble *E. s. pallidus* while by far the greater number are typical E. s. obtusirostris. All specimens have been included in the preceding tabulations of characters, allocated of course by population, not by individual.

One of the curious aspects of the present situation is the fact that a "pure" population of *E. s. pallidus* is known only from the vicinity of Palo Pinto; the single specimen from Brewster County presumably represents another but a series would be required to prove the point. A very considerable range is indicated, providing the Brewster County record is accurate; without that record, the range is indicated as a rather narrow, peripheral area west of the range of *E. s. obtusirostris.*

The only geographic variation noted in the series of *E. s. obtusirostris* is the nature of the median line. In all Texan specimens, and in most specimens from eastern Oklahoma, the line is well defined (with but three exceptions); the line is poorly defined or absent in most from Kansas and western Oklahoma. The populations in the latter region somehow may have been influenced by *E. s. pallidus,* of which the loss of the median stripe is characteristic. The Kansas-Oklahoma populations are adjacent northward to the area occupied by the race here recognized as *E. s. pallidus,* and west of the range of the more widespread, "typical" *E. s. obtusirostris.* This variety has not been recognized taxonomically because we hesitate to so regard populations distinguished by a single character such as this, especially when, as in the present case, that character is not unique but is shared by one of the adjacent races. Likewise the variety could not be included in the concept of *E. s. pallidus* since it complies with only one of the three distinctive features of that race. Needless to say, inclusion of data from specimens of this variety has considerably reduced the total percentage of separation of the two races on the basis of condition of the median light stripe.

Breckenridge in 1943 described the young of *Eumeces septentrionalis septentrionalis* (Baird). Both Texan subspecies may be distinguished readily from *E. s. septentrionalis* hatchlings as described by Breckenridge by the following differences: (1) the presence of only four or five light stripes instead of seven as in *septentrionalis*; (2) the top of the head is mottled and streaked with whitish (brick red in life) instead of being

black; (3) the dorsal margin of the upper labials is tinged with the brown dorsal coloration. In addition to the above differences the tails of the Texan forms average one-sixth longer than the body instead of being equally as long. Snout-vent lengths are very similar, the Texan forms averaging 24.5 mm. with a maximum of 25.5, whereas Breckenridge lists an average of 25.5 mm. and a maximum of 26.5 for typical *septentrionalis.*

Natural History. Individuals of both Texan races of *E. septentrionalis* are terrestrial and live under various types of ground cover such as logs, tar paper, old tins, boards, etc. L. W. Ramsey has observed the nesting of *E. s. obtusirostris* near College Station, Texas, and has kindly transmitted his notes to us. He found a nest of the species, under old tar paper, in the form of a shallow burrow in loose earth that had apparently been part of a rodent burrow. This nest was inundated during spring rains and later rebuilt, possibly by the same individual. Some time later the nest was found occupied by a *Cnemidophorus sexlineatus* indicating that some competition may exist for nesting sites between the two species.

Mr. J. E. Johnson, Jr., collected eight eggs of *E. s. obtusirostris* near Waco, Texas. His description of the nest follows: "These eggs were lying on top of the soil in a small furrow, or trench, about one inch in width, six inches in length and somewhat "S" shaped, about one-fourth inch to one-half inch in depth with a small hole extending into the sandy earth at one end." The eggs lay in full view, the hole apparently being an escape exit for the brooding female.

It is apparent that *E. s. obtusirostris* and *E. s. pallidus* prefer a habitat similar to that of *Haldea striatula* (Linnaeus) and *Leiolopisma laterale* (Say) as Strecker (1910:118-119), Taylor (1935:409) and Ramsey (correspondence) all mention the association of these three reptiles in the same habitat.

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Helminths of Cats in Eastern Kansas[1]

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The common cat, *Felis domestica* (Linne), is perhaps man's most abundant pet and doubtless his most valuable ally in controlling such vermin as mice and young rats about the premises. On the other hand, the habits of the domestic cat threaten the well-being of the home, especially of children who may play in sand and soil polluted by cats and infested with ascarid eggs or hookworm larvæ which may carry on an abnormal and harmful sojourn in the human body.

This study was made to determine the kinds and abundance of helminths (parasitic worms) in the digestive tracts of a fair sample of cats in Eastern Kansas.

Materials and Methods

The cats used in making the study were obtained from the zoology department after the students had completed the anatomical dissections. Although no definite record as to the source was kept, most of the cats were brought in groups of two or six, from farms and villages within a 100-mile radius of Manhattan, Kansas.

The stomach and intestines were removed from each cat, and the mesentery and omenta stripped off. With scissors an incision was made from the cardia to the rectum along the greater curvature of the stomach and opposite the mesenteric attachment of the intestines, after which the exposed worms were removed by forceps and placed according to habitat, in separate containers.

The three distinct anatomical portions of the gastro-intestinal tract were used in segregating the parasites; thus the helminths were placed in one of three containers labeled "stomach," "small intestine," and "large intestine." After the worms were rinsed in the containers, they were transferred to vials containing five per cent formalin. Following this the vials were labeled with the specimen number of the cat and the location from which the parasites were taken; for example, Cat No. 15, small intestine. Later, the helminths were identified and recorded.

Observations on Data

The gastro-intestinal examinations for helminth parasites proceeded until 131 cats had been examined. Almost every cat had some parasites; only two were entirely free. This gave a helminth incidence of 99.15 per cent.

Those cats having parasites in the stomach alone numbered two,

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constituting 1.6 per cent of the total number. Those showing infections of both the stomach and the small intestine numbered 65, comprising 49.6 per cent of the total. Infections of all three parts of the gastro-intestinal tract, i. e., the stomach, small intestine and large intestine, totaled 29 or 22.1 per cent; those of the small intestine alone, 26 or 19.8 per cent; and the infections of both the small intestine and large intestine, seven or 5.3 per cent.

The total number of helminths found in the 131 cats amounted to 3,772.

The identification of the helminths soon demonstrated that four species were of frequent occurrence. These included a cestode (tapeworm) species, *Taenia taeniaeformis* (Batsch); and three nematode (roundworm) species: the ascarid, *Toxocara mystax* (Zeder); the hookworm, *Ancylostoma caninum* Ercolani; and the stomachworm, *Physaloptera felidis* Ackert.

Following are notes on the species of helminths found in the examinations of the cats.

The Tapeworn, *Taenia taeniaeformis*

This tapeworm which uses mice and other small mammals to produce its larval form *(Cysticercus fasciolaris)*, was found in 59 of the cats, or 45 per cent of those examined. The range was one to 11 specimens; the total, 183 cestodes; all occurred in the small intestine.

The Ascarid, *Toxocara Mystax*

Like other ascarids, *Toxocara mystax* requires no intermediate host. The eggs incubate in the soil for a few weeks after which they contain a coiled motile embryo which is infective for cats. The nematode, *T. mystax,* was found in 111 of the animals or 84.7 per cent of the cats examined. The infections which ranged from one to 55 worms occurred mostly in the small intestine (80.9%), but frequently also in the stomach (43.5%) and occasionally in the large intestine (6.7% of the ascarids found in the gastro-intestinal tract). The total number of *T. mystax* found in the 111 cats was 1,416.

The Hookworm, *Ancylostoma caninum*

The hookworm, so-called because of the shape of its teeth, likewise requires no intermediate host for completing its life cycle. The eggs, on reaching the ground, develop rapidly and give rise to a larva which feeds on bacteria for a week and then molts to become infective for its normal host. Either by penetrating the skin or entering with contaminated food or drink, the larvae migrate over the body, through the lungs to the throat and are carried down to the intestine where they pierce the wall at intervals and feed upon the blood.

The importance of hookworms was not fully realized until 1931

when Wells discovered that the feeding hookworm sucks blood far in excess of its needs for food. After lacerating the intestinal wall and injecting an anti-coagulant, the hookworm sucks blood by rhythmical esophageal contractions until its whole digestive tract is filled and fresh blood exudes from the hookworm body to form a pool about it. Foster and Landsberg (1934) showed that the loss of blood was sufficient to cause the anaemia of hookworm patients without considering a toxic substance.

In the present study, the hookworm, *Ancylostoma caninum,* was found in 109 or 83 per cent of the 131 cats examined. The worms ranged from one to 111 per cat and totaled 1,251. Most of the infections were in the small intestine where 1,229 *A. caninum* were found. The number of the hookworms in the small intestines of the 109 cats infected ranged from one to 108.

A few hookworms were found in the stomach. From one to five *A. caninum* occurred in the stomachs of five cats, a total of 12 being recorded in this portion of the digestive tract.

What appears to be a new habitat record was established in the finding of *A. caninum* in the large intestine. Five of the cats had from one to four hookworms or a total of 10 in this portion of the intestine.

The Stomachworm, *Physaloptera felidis*

This nematode, *Physaloptera felidis,* which resembles the cat ascarid, *T. mystax,* and doubtless often has been mistaken for it was unknown in North America until 1936, when it was described as a new species by Ackert. While the ascarid more commonly occurs in the small intestine of the cat, it frequently is found in the stomach. *Physaloptera felidis* may also occur in the intestine but its usual habitat is the stomach. Unlike the ascarid *P. felidis* usually is found attached to the wall of the stomach.

In the present study this helminth was found in 67, or 51 per cent of the 131 cats. The number of parasites ranged from one to 117. Infections of the stomach numbered 60 or 45 percent of those examined. Here the range was from one to 115 specimens, the total from the stomachs amounting to 758 worms.

In the small intestine 29, or 22 per cent of the cats were infected. The range was from one to 31 *P. felidis* per cat and the total number of worms recovered from the small intestine was 159. Only three cats had *P. felidis* in the large intestine.

Discussion

The data from these examinations supplement those of Ackert (1941), who reported collections of *P. felidis* from the stomachs and

intestines of 88 of 193 cats which was considered to be convincing evidence that the cat is a regular and not an accidental host of *P. felidis.*

In the same studies Ackert found hookworms *(A. caninum)* in the stomachs of four cats, which constituted a new habitat record for that parasite. In the present study hookworms ranging from one to five in number were found in the stomachs of five cats, thus making it more evident that the stomach of the cat is one of the occasional habitats of this hookworm.

In the present study five *P. felidis* were found in the large intestine of three cats. However, as they were not attached to the wall of the colon it is possible that they were not in this portion of the intestine as parasites. Also, in the large intestine the writers found 98 *T. mystax* in 31 cats. As the large intestine is not the usual habitat of this nematode, the writers are anxious to learn if others have found this cat ascarid in the large intestine of its normal host.

From the results of this study it is obvious that the cat is a very frequent host of at least one species of tapeworm and three species of nematodes. Two of the latter, *T. mystax* and *A. caninum* may have detrimental effects on man. If large numbers of infective eggs of *T. mystax* are taken with contaminated food the larvae which migrate through the body (Danheim, 1925) may cause ascaris pneumonia.

Children playing in sand or moist soil which has been polluted by cat evacuations are subject to attacks by cat hookworm larvae *(A. caninum* or *A. braziliense)* which on penetrating the skin meet resistance from the human tissues and simply migrate along underneath the epidermis causing a tortuous sore termed creeping-eruption. Cats having access to moist sandpiles or playgrounds of children should be examined for the presence of hookworms and, if found to be infected, be treated by a veterinarian.

Summary

The gastro-intestinal tracts of 131 cats from farms and villages in Eastern Kansas were examined for helminths (parasitic worms). All but two of the cats were infected with one or more of four species of worms.

The ascarid, *Toxocara mystax,* was found in 84.7 per cent of the cats examined; as many as 55 worms occurred in one cat.

Next in abundance was the hookworm, *Ancylostma caninum,* which occurred in 83 per cent of the cats; the infection range per cat was from one to 111 hookworms. The finding of *A. caninum* in the large intestine establishes a new habitat record for this helminth.

Hookworms found in the stomach aid in establishing this organ as a habitat of *A. caninum.*

The cat stomachworn. *Physaloptera felidis,* occurred in 51 per cent of the cats, a single individual having 117 of these parasites.

Forty-five per cent of the cats had the tapeworm, *Taenia taeniaeformis,* the largest infection being 11 tapeworms.

Attention is called to the possibility of children suffering from creeping-eruption that may be caused by cat hookworm larvae.

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An Analysis of the Results of the Examination of Two Hundred Stools From Chickens

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The investigation here reported upon includes an interpretation of the results obtained by the examination of the stools of chickens. This investigation was undertaken (1) to test the validity of the method of stool examination and (2) to determine the amount of endoparasitism in chickens of northeastern Kansas in the summer of 1947.

On the authority of Dorman (1928), Dujardin while working at Rennes, France, in 1845, found that out of 190 chickens he examined, 108 were infected with *Heterakis papillosa,* a percentage of 56.8. Roth in 1903, according to Dorman (1928), found that 5.6 per cent or 13 out of 230 chickens in the vicinity of Breslau, Germany, were infected with *H. papillosa.* Ackert (1917), at Manhattan, Kansas, found that 74.1 per cent of the chickens he examined were infected with *H. papillosa.* Riley and James (1921), at Minneapolis, Minnesota, found a *Heterakis* infestation of 62.9 per cent. Dorman (1928), found a 68.4 per cent infestation of *H. papillosa* in two different groups of chickens which he examined.

Ransom (1921), examined the tracheae of 634 market chickens in the vicinity of Washington, D. C., and found that none of them had adult gapeworms *(Syngamus trachealis).*

Ackert (1930) stated that Bushnell and associates at Manhattan, Kansas, found that of 2,561 subnormal chickens brought into their laboratory between the years of 1925-1929, 33 per cent were infected with *Ascaridia lineata.*

The results obtained by previous investigators, mentioned above, were based on the identification of the adult parasite found in the bird upon autopsy.

Methods

On July 11, July 12 and August 5, 1947, two hundred stools were obtained from young chickens each weighing approximately two pounds; these were being processed at the Seymour packing plant at Topeka, Kansas. The plant, at the time of the collecting, was receiving chickens from farms in the northeastern quarter of the state. By obtaining one stool from every twenty-fifth chicken (as they were being processed), the two hundred stools represented a direct sampling of 5,000 chickens,

which in turn may be considered as a sampling of the chickens of northeastern Kansas. Each stool was placed in 5 per cent formalin in a vial. The two hundred vials were brought back to the laboratory at the University of Kansas and the stools were microscopically examined. Six slides were examined of each stool and eight slides were examined of each stool which was recorded as negative for parasites.

Data

The investigator found that the ova in the stools could be accurately identified only to the generic level. (Those found were ova of *Ascaridia, Heterakis* and *Capillaria.)*

Forty stools collected on July 11, 1947, showed that 50 per cent of the chickens were infected with helminths. These infections consisted of a 17.5 per cent infection of *Ascaridia,* a 27.5 per cent infection of *Heterakis* and a 10.0 per cent infection of *Capillaria.* These figures when totaled give an incidence of 55 per cent. This seemingly numerical inconsistency is easily explained by the fact that two chickens (5 per cent) had double infections of *Ascaridia* and *Heterakis.*

The examination of 45 stools collected on July 12, 1947, showed that 42.2 per cent of the chickens were infected with parasites. The infections consisted of a 24.4 per cent infection of *Ascaridia,* a 17.8 per cent infection of *Heterakis* and a 4.4 per cent infection of *Capillaria.* There were two cases of double infection; one of *Capillaria* and *Ascaridia* and one of *Capillaria* and *Heterakis.*

The examination of 115 stools collected on August 5, 1947, showed that 45.2 per cent of the chickens were infected with parasites. These infections consisted of a 26.1 per cent infection of *Ascaridia,* a 20.9 per cent infection of *Heterakis* and a 2.6 per cent infection of *Capillaria.* There were five cases of double infections of *Ascaridia* and *Heterakis.*

The examination of the two hundred stools indicated that 45.5 per cent of the chickens were infected with endoparasites. These infections consisted of a 23.6 per cent infection of *Ascardia,* a 21.8 per cent infection of *Heterakis* and a 4.9 per cent infection of *Capillaria.*

Discussion and Conclusions

The question arises as to the accuracy of the results from the examination of only one stool from an individual chicken. Some of the stools that were diagnosed as negative possibly came from chickens that were infected with parasites. To test this possibility, 50 chicken entrails were obtained from the Seymour plant at Lawrence, Kansas, in the month of December, 1948, and stools from these entrails were examined, using the same procedures as were used in the initial stool

examinations. This time, however, after a stool had been examined, the entrail was opened and examined for any adult parasites. This allowed the investigator to obtain the per cent of error incurred by using the procedures already mentioned before: the number of correctly diagnosed infections (by stool examination) divided by the true number of infections (by gut examination) gave the per cent of error. In this subsequent study it was found that:

1. The diagnoses of chickens infected had an error of 48.8 per cent.
2. The identification of *Heterakis* infections had an error of 45.0 per cent.
3. The identification of *Ascaridia* infections had an error of 42.9 per cent.
4. *Ascaridia* and *Heterakis* infections were mis-identified for each other in 4.3 per cent of the stools.
5. Because of limited material, no error could be determined for the *Capillaria* infections. (The entrails that were examined were only the portions between the gizzard and the anus. *C. annulata* inhabits the crop, esophagus and mouth.)
6. Adult tapeworms of the genus *Raillietina* were found in the entrails of five chickens. No adults or earlier stages in the life history were found in the stools. The suggestion is that stool examination does not reveal the presence of this genus.

Using the data obtained from this subsequent study to interpret the results of the initial study it is obvious that the results of the stool examinations alone (made in the initial study), yield a figure of incidence of infection that is incorrect because it is too low. A more nearly correct figure for the incidence of infection would be obtained by dividing the stool-diagnosed percentage of infection by the per cent of error, namely the difference in percentage between infections found by examining the stool and those found by examining the gut. For the 200 chickens used in the initial study, the percentage of infection is thus corrected from 45.5 per cent to 93.2 per cent. For each of the parasites concerned, the two percentages are as follows:

Ascaridia, 23.6 and 55.0. *Heterakis,* 21.8 and 48.4. *Capillaria,* 4.9 found; maximum infection not estimated.

Summary

1. One stool from each of 200 domestic chickens from northeastern Kansas was examined for ova of helminth parasites.

2. The results of examination of fifty additional stools of like material were compared with the results of examination of the gut of the same individuals.
3. Ova of *Ascaridia* and *Heterakis* were found in the stool and adults of each were found in the entrails.
4. Ova of *Capillaria* were found only in the stool, but no adult was found in the entrail.
5. One cestode, *Raillietina,* was detected in the gut but not in the stools.
6. An error of approximately 50 per cent was found in diagnosing infections of nematodes by relying on the detection of ova of *Ascaridia* and *Heterakis* in stools.
7. When the results of examinations of single stools are corrected on the basis of autopsy studies, chickens of northeastern Kansas appear to be parasitized as follows: *Ascaridia,* 55 per cent of the chickens; *Heterakis,* 48 per cent; *Capillaria,* 5 or more per cent.

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Post-Partum Parental Observances of the Mohave Indians *

GEORGE DEVEREUX

Introduction

Since the Mohave attached a great deal of importance to the process of gestation, and believed that various rites performed at the climatic moments of the life-cycle in general, and of the gestation process in particular, were of prophylactic value, the parents of the newborn were expected to observe various taboos, and to practice various rites, in order to insure their own welfare, as well as that of the child. It is noteworthy, however, that the avowed purpose of the majority of post-partum observances is the protection of the child, rather than the welfare of the parents. This is probably due to the fact that the Mohave considered parenthood simply as a normal part of life. Therefore, once the child is born, attention is usually shifted from the mother to the infant. This tendency is probably further strengthened by the fact that, according to the medical observations of Hrdlicka (10), the post-puerperium of Mohave women tends to be better than that of Whites. In fact, according to this writer, the Mohave woman usually rises from her bed two or three days after her delivery, and, in some instances, even on the day of childbirth.

Post-partum psychoses were not reported. (*)

The first part of this study will consist of a description of post-partum parental observances, while the second part will be devoted to an analysis of some of the psychic determinants of these practices.

DATA

I. *Purification Rules*

(A) *The Bath:* On the day after delivery the mother bathed in warm water. (8) Only after her ritual bath was she permitted to handle her infant. On four successive days both husband and wife bathed in the morning and in the evening, in warm water. Were the parents to bathe in cold water, "their child would become feverish, and its body would begin to swell up. The illness settled in the baby's bowels, and it died". While taking these baths, both parents also "soaped" themselves with leaves of a "light grey shrub" (probably yucca) which, when rubbed, crumbled and mixed with arrow-weed, gave a rich lather.

The mother was bathed by her own mother or grandmother, while the father, according to Hivsu: Tupo:ma, was bathed by his wife.

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* The original field work here reported was done under the auspices of the Musee de l'Homme, Paris.

(*) One case of what may possibly have been a psychosis following miscarriage will be described elsewhere.

According to Tcatc, however, "If the couple was staying with the wife's folks, the father had to bathe himself. On the other hand, if his own mother or grandmother happened to be present, one of them undertook to bathe the new father. Only a man's own mother or grandmother may bathe him". Since the custom is now more or less obsolete, it was impossible to ascertain precisely what activity the expression "to bathe the father" implied. The fact that the mother was bathed by the parent of her own sex, while the father was bathed by the parent of the opposite sex probably indicates that "bathing someone" was thought of as an essentially feminine service, probably because infants are usually bathed by women. The probable purpose of bathing was to remove the odor of blood, which is greatly detested by the Mohave.(5)

(B) *Bed of Hot Ashes:* For one month after childbirth the mother spent approximately one hour a day on a bed of hot ashes, similar to the one used in puberty ceremonies. At the end of this month she was subjected to a ritual which is identical with the puberty rite (14) and, hence, need not be described in this context.

II. *Cosmetic Observances:*

(A) *Scratching Sticks:* According to Drucker (8) both parents used scratching sticks, while according to Wallace (15), only the mother of a newborn child used a scratching stick of shredded arrow-weed. According to my informants "Women use scratching sticks made of strips of bark, or of small rags attached to a twig of arrow-weed. These scratching sticks are used for one month. Should the new mother touch or wipe her face with her hands, she will have liver-spots wherever her hand had touched her face. Tcatc, the perennial skeptic, disagreed, however, with this well documented statement. According to Wallace (15) the new mother also had to use a scratching stick, if she wished to touch her hair.

(B) *Paint:* As stated elsewhere (2) the prospective father could paint his face until childbirth, while the mother had to stop using paint one month before her expected confinement. She was also supposed to refrain from painting her face for four days after childbirth, lest her child should swell up and be covered with liver-spots. According to Drucker (8), however, both the new mother and her infant were immediately painted with a red ointment.

III. *Food, Drink and Smoking Observances.*

(A) *Food Taboos* played a considerable role in Mohave post-partum observances, and, despite many minor differences between the

practices recorded by Kroeber (11), Hrdlicka (10), Drucker (8), Wallace (15) and myself, formed a consistent pattern.

(1) *Quantitative Taboos:* According to Hrdlicka (10), the new mother ate no solid food for one day, and merely drank some warm water and soup. According to Drucker (8) the new mother fasted for four days, and, furthermore, ate sparingly for twenty days after the birth of her first child, and for ten days only after the birth of subsequent children. According to Wallace (15) "she eats sparingly for 'quite a while'." The fact that my own informants mentioned no quantitative restrictions whatsoever, is, of course, not incompatible with these data, since it is obvious that the normal food-intake of the nursing woman would be automatically decreased by the fact that many of the standard items of Mohave diet were taboo for her.

(2) *Qualitative Taboos:*

(a) *Salt* was one of the principal dietary items prohibited after the birth of a child. The exact length of the period during which the mother could not eat salt is given by Kroeber (11) as one month, by Hrdlicka (10) as one month for the first child, and two or three weeks for subsequent children, by Drucker (8) (though only indirectly), as four days, and by Wallace (15) as four days. Dr. Nettle stated that the salt taboo was observed only after the birth of the first child, and lasted a month. According to Kroeber (11), Drucker (8) and Wallace (15) the father also observed the salt-taboo for the same length of time as the mother did. Acording to my informants, the mother did not eat salt for one month, and the father for four days, "lest a violation of this taboo should make the child cough, and cause its tongue to be coated".

(b) *Meat.*

(a) *Meat in general* was taboo for the mother, according to Kroeber (11) for one month, according to Hrdlicka (10) for one month after the birth of the first child, and for two or three weeks only after the birth of subsequent children, and according to Drucker (8) (inferentially) for four days. This author states that a (four day) meat-taboo was also observed by the father. Wallace (15) mentions no general taboo on meat. My own informants stated that the mother refrained from all meat for one month, and the father for four days. At the end of that period both parents were once more free to eat meat, although the husband had to give away his own kill. "The very superstitious ones observed this rule until the child was seventeen years old". During this period the family obtained meat from relatives, and,

perhaps, specifically from the recipients of the meat which the father had to give away. Such mutual gifts never degenerated into formal barter, however.

(β) *Rabbit:* According to Wallace (15) the mother avoided rabbit meat for two years, and the father for four days, because it caused the child to have earache and a rash on its body. My informants stated that both parents refrained from eating the meat of the jackrabbit for an indeterminate length of time, in order to protect the child against "running ears" (i.e. a discharge from the ear). The meat of cottontails was likewise taboo for both parents for an indeterminate length of time. A violation of this taboo caused the child's body to be covered with sores. (*) "If the child lived, the more conservative Mohave parents, and especially the mothers, observed the jackrabbit and cottontail meat taboo for a period of time ranging in duration from a few months to twenty and even twenty-five years". "In fact, some women never ate rabbit-meat until after they reached menopause, because not until then did all their children reach adulthood. A few husbands also refrained from rabbit-meat for a similar length of time."

(γ) *Woodrats:* According to Wallace (15) women did not eat the flesh of this rat, lest the child should contract a skin disease.

(δ) *Fish:* According to Wallace (15), fish was not taboo.

(c) *Vegetables:* The literature on Mohave post-partum observances, contains no references to any taboo on vegetable foods. Wallace (15) merely mentions that mushrooms were *not* taboo. My own informants stated, however, that women who partook of blackeyed peas, "a kind of yellow beans" (marik akwac), screw-beans ("which are a sort of mesquite beans, a:ic",) "too soon after childbirth", became barren. All informants, with the exception of Tcatc, also stated that, after childbirth, corn "corrupted the blood of women, and made them barren". These taboos, though checked rather carefully, are hard to reconcile with the list of prescribed foods given below.

(d) *Prescribed Diet:* According to Hrdlicka (10) the new mother ate mainly soup. Wallace (15) states that the diet of the young mother consisted chiefly of wheat-mush and boiled corn. According to my informants, women who had given birth recently ate "mushy food, such as ground boiled wheat or corn ("something like porridge") for quite

(*) It is interesting to note in this context that whenever a cottontail is found hiding in its burrow, the Mohave thrust a stick into the warren, and, twisting the stick into the cottontail's skin, drag it out of its hole. This would obviously cause the rabbit to bleed. The miraculous healing of the wound of a dead rabbit is mentioned in a so-called Coyote Tale (4).

a while". "She must eat soft foods, because after childbirth her teeth are soft, and hence, likely to develop caries if she ate hard food". (*)

(B) *Drink:* According to Hrdlicka (10), during the first four days after childbirth the woman does not "eat" at all, but merely drinks warm water and soup. According to Drucker (8) both parents drink only warm water, while Wallace's statement (15) seems to indicate that only the mother is expected to drink warm water. According to my own informants, "however warm the weather may be during and after childbirth, the woman drinks only warm water for quite a while." After her first delivery she also drank a decoction of the leaves of "a weed with red flowers". Unlike some other Yuman-speaking tribes, the Mohave did not oblige the young mother to drink an emulsion of ground shells, in order to prevent subsequent barrenness, perhaps because shells were rather rare in Mohave territory, and would have had to be imported from other tribes (6) for this purpose.

(C) *Tobacco:* According to Kroeber (11) neither parent smoked for one month following birth, while according to Wallace (15) the father alone refrained from smoking for four days. According to my own informants both parents were free to smoke after childbirth.

IV. *Various Activities.*

(1) *Sexual relations* could be resumed as soon as the parents wished to do so. Of course, they were presumably never resumed on the day of birth, since at that time the woman "still smelled of blood". The fact that a new pregnancy frequently caused a disappearance of the milk flow, forcing the woman to interrupt nursing (1) indicates that sexual relations were resumed rather soon after childbirth.

(2) *Work* was resumed as soon as the woman was able to take care of her various household duties. In the winter, however, she stayed indoors for eight days, for fear of chilling her body, and left the house only in order to urinate or defecate.

(3) *Contact Taboos:* While the infant is still small, the mother must not put her hand into a bag, nor may she touch a stocking or any other baggy object, lest her son should have one oversized and one undersized testicle. This was objectionable on esthetic grounds only, since it was not believed to impair potency. This deformity, called hamauek, which was formerly cured by shamans, is no longer treated at present, because no living shaman specializes in the treatment of this disorder. (†) It is interesting to note that a post-partum violation of

(*) The statement that the new mother's teeth are soft (decalcified) and likely to become carious is, of course, medically correct, although the conclusion that she must therefore eat only soft food is incorrect.

(†) The Mohave knew neither the cause nor the cure of an undersized penis.

this taboo was not stated to cause girl-children to develop asymmetrical labia. This may be a mere oversight, since a violation of this taboo during pregnancy is supposed to cause boys to have asymmetrical testes, and girls asymmetrical labia. (2) Both parents were also forbidden to touch hamkye and kwarau, described as two kinds of green water-plants, 6-10 inches high, and ihor, said to be a tree that looks like a "straight willow", lest the child should swell up in "transversal ridges", "Its heart and bowels will also seem to swell, and it will seem poisoned. This disease kills children before the day is over".

The Deliberate Violation of Taboos for the purpose of "killing" or "harming" one's child was unknown. Unwanted children were disposed of by burying them alive (3), rather than by a purposive violation of post-partum taboos.

Interpretation

(1) *Hostility Toward the Child:* Careful studies of the dynamics of maternal overprotection indicate (12) that elaborate precautions taken to safeguard the child against various calamities reveal the presence of unconscious hostile parental impulses toward the child. This interpretation is especially convincing when the precautionary measures and prophylactic taboos genuinely inconvenience the parents, and, therefore, probably represent attempts to atone for unconscious hostilities toward the child. I have, furthermore, described in another context numerous other beliefs and practices indicative of the presence of such hostile wishes. (7) Hence, it is felt that the existence of aggressive parental impulses does not stand in need of elaborate proof.

(2) *Oral Aspects of Hostility:* The large number of eating, drinking and smoking taboos suggests that parental aggression against the newborn is—perhaps in imitation of the suckling's own aggressions—primarily of an oral-cannibalistic character. This inference is supported by the fact that, according to the Mohave, some "unnatural" children (i.e. snake-headed monsters and future shamans) tend to bite the maternal nipple. (1) At the same time, the fact that the woman eats primarily liquid or mushy food, of a type which is also used to feed the newborn before the milk-flow starts (1), snake-headed monsters whose bite is feared, and some orphans, whom no one wishes to nurse (1), suggests a deepgoing identification of the mother with the chid, which is probably rooted in her envy of the child's passive dependency. This inference is supported by what has been said elsewhere concerning the oral-dependent tendencies of Mohave women. (1) This identification is also obvious in the fact that the parents are bathed by their own mothers, as though they too were newborn infants. It is also most significant that

whereas the eating of tabood *meat* harms the *child,* the eating of forbidden *vegetable* (i.e. baby) foods is supposed to make the *mother* barren.

(3) *Castrative Aggression:* The taboo against putting one's hand into baggy objects, which is said to cause an unequal development of the testes, (respectively of the labia?) suggests that castrative wishes are also present. Furthermore there are reasons to assume, that these castrative wishes are, by means of the equation foetus=phallus, inextricabl ably interwoven with aggressions against the body-content of the mother, witness, among other things, the manner in which the Mohave drag the cottontail—whose flesh is taboo both during pregnancy (2) and after delivery—from its burrow. In brief, these beliefs indicate that, in robbing the maternal body of its contents, one also damages the infant's genitalia. In this sense birth appears to be unconsciously equated with the simultaneous castration of both mother and child. (*)

(4) *Purification-Rites,* which, as stated above, are similar to puberty rites, suggest that birth is thought of as an important change in the sexual status of the woman. In fact, it is known that a woman ceases to be designated as masahay (girl) and begins to be called thinyeak (woman) only after she has borne a child. It is also important to recall in this context that both real and phantom foeti are believed to be formed of accumulated menstrual blood (2, 7). The fact that these rites are also identical with the purification rites for patients haunted by evil sexual dreams about dead relatives or spouses, fully substantiates what has been said elsewhere concerning the presence of unconscious fantasies that all children are essentially supernatural, and/or ghostly and/or incestuously conceived beings. (7)

(5) *Couvade:* The psychic determinants of the practice of causing the father to submit to the post-partum observances imposed upon his wife have been fully analyzed by Reik (13), and need not therefore be discussed in this context, except to point out that the hunting taboo imposed upon the new father is a particularly striking indication of an attempt to control, both directly and indirectly, parental aggressions toward the newborn rival for the wife's affections. This jealousy is an especially important force in Mohave psychology since, due to the instability of marriages and the relatively greater stability of the parent-child relationship in general, and of the mother-child relationship in particular, the child is quite often a very real rival of the father for the mother's affections. The fact that the new father is bathed by

(*) If this inference is valid, then the argument over whether the birth-trauma or castration-anxiety is the nucleus and prototype of all anxieties loses some of its meaning.

his own mother suggests that he too envies the child's state of blissful dependency which he, as an adult, is constantly forced to renounce, both directly and indirectly, e.g. by not stimulating orally his sexual partner's nipples, (1, 5) and in many other and more practical ways as well.

Conclusion

All things considered, the primary purpose of Mohave post-partum observances seems to be the deflection of parental hostilities from the child, atonement for these hostile wishes in the form of inconvenient taboos, and the protection of the child against precisely those types of (oral-cannibalistic and castrative) hostile wishes which parents usually have toward their newborn children. In view of Freud's analysis of the function of taboos (9), it is not surprising to find that these rites and counter-phobic attitudes apparently enable Mohave parents to control certain aggressions which, in our own society, sometimes culminate in post-partum psychoses. (16) This inference is strongly supported by the fact that a woman, who after her miscarriage had a transitory confusional episode, expressed no hostility whatever toward the miscarried child during the entire period of her hospitalization.

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Supplementing Broiler Rations with Distillers Solubles

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Certain wastes, recovered from the process of distilling butyl alcohol from grains, have been found to be beneficial for livestock feeding. Schlamb and Winter (1948), working with one of these products, found that distillers dried solubles (hereafter referred to as D.D.S) have been used successfully to replace cereal grains and animal proteins. These workers showed that five percent D.D.S., replacing animal protein in chick rations, gave improved growth. Ten percent was not proportionately beneficial over five percent D.D.S. In tests with laying hens, rations containing 10% D.D.S. in place of animal proteins and supplemented with riboflavin gave satisfactory egg production. Scott and Glista (1948) reporting on high energy rations for broilers found that a ration containing four percent corn D.D.S. and three percent brewers dried yeast could replace three percent liver meal and give satisfactory growth so long as the protein, choline, and riboflavin were adjusted. He was able to obtain an average of 1,024 grams for cockerels and 889 grams for pullets to eight weeks of age on the above trial. The fact that D.D.S. also contains several of the water soluble vitamins and various unidentified nutritive factors has been demonstrated by several other workers. When D.D.S. is treated with certain fermenting bacteria, an added benefit in results is usually obtained.

The feeding trials reported herewith are an attempt to compare the efficiency of the K.S.C. and Illinois high energy diets supplemented with five percent D.D.S. and two percent B.Y-500*, the latter a Butyl fermentation soluble. The D.D.S. used in this test was made from grain sorghums and was produced at Atchison, Kansas.** Twenty-five sexed cockerels of the Kansas White Plymouth Rock strain were used in each group. The trial lasted for eight weeks, with weights being taken at start, four weeks, and eight weeks.

Although not conclusive, the results show a general tendency for improvement of growth, and greater efficiency of feed utilization where D.D.S. and B.Y-500 were fed. The sexing process was not very accurate, resulting in uneven numbers of males in each lot. The data listed herewith are for cockerels only. The maximum growth was obtained where the Illinois ration was supplemented with D.D.S., which produced 2.73-

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*Furnished through the courtesy of the Commercial Solvents Corp., Terre Haute, Indiana.
**Furnished through the courtesy of Midwest Solvents Co., Atchison, Kansas.

pound cockerels on 6.32 pounds of feed, or one pound of broiler for every 2.31 pounds of ration fed. Supplementing the K.S.C. broiler ration with B.Y-500 gave practically the same growth (2.72 pounds av. wt.) on less feed (6.04 pounds), or one pound of broiler for only 2.22 pounds of feed. K.S.C. broiler ration plus D.D.S. produced birds averaging 2.48 pounds each on 5.51 pounds of feed, or one pound of broiler for every 2.24 pounds of feed. The unsupplemented K.S.C. broiler ration, used as the control, produced birds averaging 2.47 pounds or 1,122 grams which exceeded the best weights reported by Scott and Glista. It is possible that some of this improvement may have been due to the strain of chickens used.

The growth and economy of feed utilization attained in this test exceeds all other feeding trials for broilers carried on by this station. Since the D.D.S. are readily available in Kansas at a nominal cost, the broiler producers of the state could well afford to include them in their rations.

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How Hens Perform in an Ideal Environment

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A unique experiment has been in progress at Kansas State College since 1942. Poultry research workers at this institution have shown that temperature, humidity, and light influence a hen's performance. It has long been known that laying hens exhibit certain seasonal trends in the number and constitution of eggs laid, and in their own behavior and physiological reactions.

For the purpose of such a study, a separate laying house was constructed consisting of three rooms, each capable of housing 50 layers. The foundation stock, equipment, arrangement, and feed in the three rooms are the same. The three environmental factors considered are temperature, humidity, and length of day. In room 1, these three factors are allowed to fluctuate normally with the season. Room 2 is designed so that the temperature and humidity fluctuate with the season, but the birds are given equal periods of artificial daylight and darkness. Room 3 is equipped so that the temperature is maintained uniformly throughout the year at 65° F. The moisture is maintained at 65 percent relative humidity, and there are equal periods (12 hours) of artificial daylight and darkness. Special refrigeration and heating equipment make it possible to maintain constant temperatures in this room.

An experiment as closely controlled as this one lends itself well to the study of many different factors. Some of those studied are: egg production, egg size, egg shell thickness, molt, broodiness, mortality, body weight, blood and meat spots, feed consumption, hatchability of eggs, and calcium content of the blood.

The results of this experiment are varied and interesting. It was shown that hens kept under the ideal environment in Room 3 laid only a few more total eggs during the year than did those in Rooms 1 and 2. It was demonstrated, however, that hens in Room 3 did not go into a slump during periods of very hot or very cold weather, as did the other two rooms. They also laid more eggs during the fall months, but laid fewer eggs during the spring peak, a time when most hens lay at the highest rate. There tended to be a rather consistent difference in egg size between the three rooms. Hens in Room 3 laid smaller eggs during the fall and winter months, but laid larger eggs during the summer months than did birds in the other two rooms. Birds in Room 2 laid eggs that were intermediate in size between those of Room 3 and Room 1. The results of this phase of the experiment would indicate that high summer

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temperatures cause hens to decrease the size of the eggs they lay, while winter temperatures tend to encourage hens to lay eggs of relatively large size. It was also shown that eggs laid by the birds in Rooms 1 and 2 had thinner shells during hot weather than did those laid by the birds in Room 3. During the winter months, hens in rooms 1 and 2 laid eggs with thicker shells than those in Room 3. The shell thickness varied a great deal with the season in the two uncontrolled pens, while it remained fairly constant in the controlled pen.

Molt has always been a problem, as hens normally molt at least once each year and usually stop laying until the molt is finished. This experiment has shown that hens kept in the uncontrolled room (Room 1) molted in the same manner that hens usually molt, while those birds kept under constant conditions delayed the molt until much later in the fall and did not molt as heavily. Birds in Room 2 were intermediate in their molt between those in Rooms 1 and 3. Although the normal time for hens to molt is in the fall following a year of laying, it is not unusual for very early-hatched pullets to go into a fall molt soon after laying starts. The molt behavior of February-hatched pullets was studied and it was found that pullets in Room 1 molted in the fall, while a very small percent of those in Room 3 showed any fall molt. Again, hens in Room 2 were intermediate in their degree of molt. The fact that only a few hens which are kept under ideal conditions ceased egg production as a result of molt gives a distinct advantage over birds kept under normal conditions, as egg prices are highest during the fall months.

Although mortality varied among the rooms from year to year, there appears to be no consistent difference by rooms so far as death loss is concerned. The tendency for birds to lay eggs with blood spots does not seem to be associated with environmental conditions but is closely related to the heredity of the individual. The eggs produced by hens in Room 3 consistently gave slightly better hatchability than eggs from hens kept in either of the other two rooms.

This experiment, which has been in progress for the past seven years, has supplied the "why" to many functions of the hen which were not well understood, and although some phases of it are not of great practical value, others are of considerable economic importance. Under farm conditions, extreme temperatures can be modified by the use of a straw loft in a poultry house. It is known that a properly constructed straw loft will maintain the inside of the house about 10° F. warmer in winter and 10° F. cooler in summer. Such information fits together with other bits of knowledge to help keep poultrymen better informed on improved methods for managing their flocks.

An Assay of Stramonium

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Much work has been completed on *Datura stramonium*, to determine the factors affecting the amount of alkaloid present, the place of occurrence of the alkaloids in the plant, and the ash and acid-insoluble ash contents of the plant as a whole and the various parts of the plant. Relatively little work has been done to ascertain the percentage of alkaloids present in the various fractions of the ground drug.

Therefore, Lot 33A of *Datura stramonium,* consisting of the dried leaf and flowering tops of the plants, was ground in a Wiley mill and passed through a 2 mm. sieve (#10).

250 gram and 100 gram samples of the ground drug 33A were placed in tared U.S. Bureau of Standards sieves and hand shaken from 10 to 30 minutes. At the end of that time, the sieves were weighed to determine the percentage of the sample contained in each. (See Table I). The percentage of the sample remaining in the #20 sieve varied from 2.0 to 4.1% for eight samples; #40 sieve, 29.8 to 34.2%, eight samples; #60 sieve, 32.1 to 36.4%, eight samples; #80 sieve, 10.3 to 11.6%, eight samples; pan, 16.5 to 20.0%, eight samples. One ten-gram sample was passed through the 1-mm. sieve of the Wiley mill and shaken 15 minutes. The percentages of the powders contained in each sieve totalled from 99.1 to 101.1% for each sample. The powders of the same size were mixed and assayed for ash, acid-insoluble ash, and alkaloidal content.

The ash from each fineness of ground drug was determined from samples weighing between two and three grams. These samples were ignited in a muffle furnace at a temperature of 480 to 485 degrees centigrade until no carbon was present. The percentage of ash obtained from the ground drug contained in the number 20 sieve averaged 21.5%; #40 sieve, 18.8%; #60 sieve, 16.0%; #80 sieve, 15.3%; pan, 28.5%. (The United States Pharmacopoeia places no limitation upon stramonium for total ash).

The acid-insoluble ash was next determined for each fineness of ground drug by treating the ash obtained under total ash with 25 cc of diluted hydrochloric acid. The percentages of acid-insoluble ash obtained from the ground drug contained in the #20 sieve averaged 0.305%; #40 sieve, 0.403%; #60 sieve, 0.456%; #80 sieve, 0.399%; pan, 11.05%. The Pharmacopoeia sets the acid-insoluble ash limits of *Datura stramonium* at not more than 4%. This acid-insoluble portion of the ash reveals the relative proportions of sand and dirt in each sample.

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Each fineness of ground drug subjected to alkaloidal determination by the method outlined in the U.S. Pharmacopoeia XII yielded the following results: #20 sieve, no assay; #40, 0.40%; #60, 0.21%; #80, 0.196%; pan, 0.343%. The USP limitation on the total alkaloids present in *Datura stramonium* is not less than 0.25%.

From these results, it may be concluded that this sample of *Datura stramonium,* collected in Kansas, meets the official requirements for acid-insoluble ash and that further work can be done to determine which portion of the ground powder gives the best yield of total alkaloids.

Table I. Per Cent Each Size Powder in Complete Sample of Drug

Sieve No.	Sample No.											
	A	B	C	D	E	F	G	H	I	J	K	L
20	3.3	4.1	3.2	3.1	3.1	3.2	3.0	2.4	2.9	2.1	2.0	0.0
30												0.9
40	33.9	34.0	32.7	34.2	32.5	32.7	34.2	31.7	30.2	30.6	29.8	11.4
50												26.3
60	32.1	32.1	32.8	34.1	34.0	32.8	35.0	35.8	35.8	36.4	36.2	12.8
80	11.4	11.4	11.6	10.3	11.1	11.6	10.5	11.1	11.6	11.6	11.1	20.1
90												
100												
pan	19.4	19.4	19.6	18.5	19.2	19.6	16.5	18.6	19.2	18.5	20.0	27.8
TOTAL	100.1	101.0	99.9	100.2	99.9	99.9	99.2	99.6	99.7	99.2	99.1	99.3

A—250 Gm. shaken 10 min.
B—250 Gm. shaken 10 min.
C—Sample B shaken 5 min. more—total 15 min.
D—250 Gm. shaken 10 min.
E—Sample D shaken 5 min. more—total 15 min.
F—Sample D shaken 15 min. more—total 30 min.
G—100 Gm. sample shaken 15 min.
H—100 Gm. sample shaken 20 min.
I—100 Gm. sample shaken 20 min.
J—100 Gm. sample shaken 30 min.
K—100 Gm. sample shaken 20 min.
L—10 Gm. sample passed through 1 mm. sieve of Wiley mill. Shaken 15 min. (micro sieves were used).

Table II. Per Cent of Total Ash for Each Sieve-Size Ground Drug

Size Sieve Containing Sample	% Total Ash
No. 20	21.5
No. 40	18.8
No. 60	16.0
No. 80	15.3
Pan	28.5

Table III. Per Cent of Acid-insoluble Ash for Each Sieve-Size Ground Drug

Size Sieve Containing Sample	% Acid-Insoluble Ash
No. 20	0.305%
No. 40	0.403%
No. 60	0.456%
No. 80	0.399%
Pan	11.05%

Table IV. Per Cent Total Alkaloids Present in Each Fraction Ground Drug

Size Sieve Containing Sample	% Total Alkaloids
No. 20	insufficient sample
No. 40	0.400%
No. 60	0.212%
No. 80	0.196%
Pan	0.343%

Bird Studies

(Some New or Infrequent Visitors to Kansas)

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RICHARD H. SCHMIDT, Canton, Kansas

The study and collecting of birds is a most interesting and rewarding hobby. Central Kansas is in the path of many migratory species of birds. In addtion to this, many species which are commonly found great distances both east and west of here are many times collected in this area. This last statement is in accord with findings of Mr. Frank W. Robl, bird bander of Ellinwood, as well as other observers.[1]

The fact that not many bodies of water, and no great abundance of trees together with the comparatively small size of the trees that we have makes it much easier to locate the birds which come our way than it would be were our ponds and lakes more abundant and our trees larger and more numerous.

We felt ourselves fortunate in taking a Chestnut-sided warbler in Marion County, for it appears that this species is uncommon in this section of the state. Mr. W. S. Long reports this species as a rare migrant in the extreme eastern part of our state,[2] as does also Dr. E. Raymond Hall.[3] Col. N. S. Goss reports he has never seen one in the state.[4] We consider almost equally important the finding of a Luzuli bunting. This specimen was captured in a shelter belt in Marion County. Col. Goss reports this species as a rare summer resident of the western part of the state.[5]

The summer of 1934 was a particularly dry season. Lake Inman in McPherson County was one of the few bodies of water remaining in central Kansas. As a result it became the gathering place for many water and shore birds. On August 9, 1934, we secured a female specimen of the Louisana heron. This species is not listed in *History of the Birds of Kansas* by N. S. Goss, *Checklist of Kansas Birds* by W. S. Long, or *Birds of Kansas* by A. L. Goodrich. We are inclined to agree with Dr. H. C. Oberholser, senior biologist section of Wild Life Survey, Washing-

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[1] Personal letter from Mr. Frank W. Robl: 1949.
[2] Personal letter from Mr. W. S. Long: 1940.
[3] Personal letter from Dr. E. Raymond Hall: 1949.
[4] Goss, Col. N. S., *History of the Birds in Kansas*, p. 558, Topeka, 1891.
[5] *Ibid.*, p. 491.
[6] Personal letter from H. C. Oberholser: 1948.
[7] Personal letter from Dr. E. Raymond Hall: 1949.

ton D. C., that this is a valuable record from Kansas.[6] Post-season stragglers have been reported in Missouri and Indiana.[7]

The laughing gull that we are presenting was taken from a small flock of Franklin gulls on May 15, 1933. The capture was made in a field in Marion County. To make certain of the identification of this specimen it was sent to the Smithsonian Institution where it was identified by Herbert Freidman, Curator of the Division of Birds. This bird is not listed by Long, Goss, or Goodrich.

Our Western Grebe is a female that was found dead on the shore of Lake Inman on October 4, 1930. The Western Grebe is a bird of the far West, occasionally seen in the Central States.[8] Dr. E. Raymond Hall reports two having been taken near Lawrence.[9] The first specimen reported in the state was by Prof. F. H. Snow in 1887.[10]

The birds mentioned in this paper are in the collection of the taxidermist, Richard H. Schmidt of Canton, Kansas. This collection consists of more than two hundred species of birds that have been collected from central Kansas.

[8] Goodrich, A. L. *Birds of Kansas,* p. 147, Topeka, 1946.
[9] Personal letter from Dr. E. Raymond Hall: 1949.
[10] Goss, Col. N. S., *History of the Birds in Kansas,* p. 8.

Observations on the Seed and Germination of *Setaria italica* (L.) Beauv.

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Literature contains description of the seed and germination of the caryopsis of grasses, but no mention has been made of a "flap-like" structure in the lemma and "roothair-like" structures on the coleorhiza. Moreover, the "flap-like" structure in the lemma is common in the genera *Setaria, Echinochloa, Eriochloa* and possibly others. As a result the author will give an account of his observations.

The Caryopsis

The caryopsis is about 2 mm long and its shape is as indicated on Plate 1, Figures 1 and 2. The palea and lemma are straw-yellow in color as is the endosperm. The embryo is brown. As in some other cereals the caryopsis remains enclosed by the lemma and palea; the palea having its margin overlapped by the lemma. In the lemma, as shown by Plate 1, Figures 1, 2 and 3, there is a "flap-like" structure, which is apparent even in the dry caryopsis. The endosperm constitutes two-thirds of the bulk of the caryopsis and the embryo approximately the remaining one third. Starch fills the cells of the endosperm. Tests show the presence of oil.

The Embryo

The embryo lies embedded in the endosperm in a median plane extending a little over three-fourths across the endosperm lengthwise with the coleorhiza within the "flap" of the lemma. Within the coleoptile are several primordial leaves. The embryonic axis consists of an hypocotyl, a mesocotyl and an epicotyl.

Germination

In germination, after a period of 12-15 hours, the embryo increases in size and the coleorhiza emerges, pushing out the "flap". Observations

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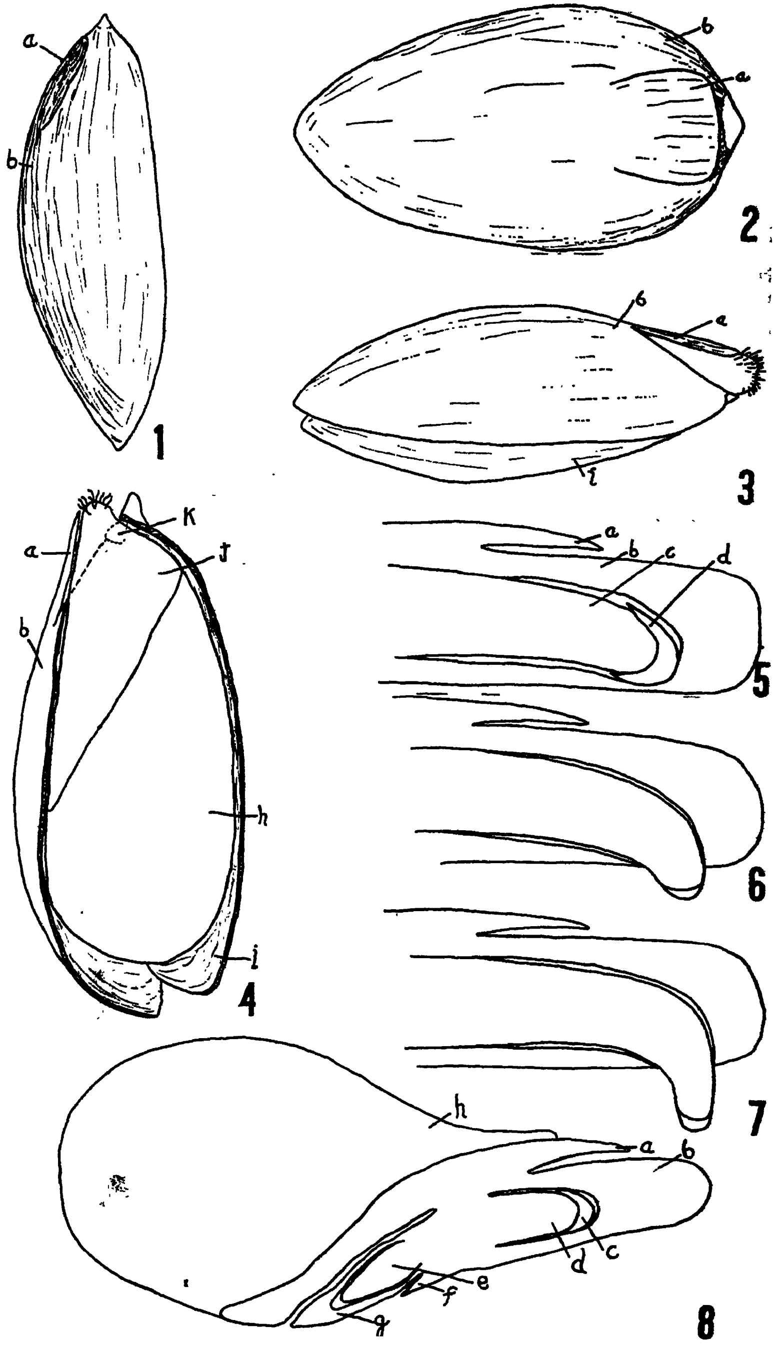
PLATE I, FIGURES 1-8 ☛

1. A lateral view of the caryopsis showing: a, flap of lemma; b, lemma. X 30.
2. The abaxial surface of the caryopsis showing: a, the flap of the lemma; b, the lemma. X 30.
3. A lateral view of the caryopsis showing: a, flap of the lemma; b, lemma; i, palea. X 30.
4. A longitudinal section of the caryopsis 12-15 hours after germination showing: a, flap of lemma; b, lemma; h, endosperm; i, palea; j, embryo; k, lodicule. X 33.

5, 6, and 7. A diagrammatic section through the coleorhiza showing the growth of the primary root through the coleorhiza: a, scutellum; b, coleorhiza; c, primary root; d, root cap. X 75.

8. A diagrammatic section through the embryo and endosperm showing: a, scutellum; b, coleorhiza; c, root cap; d, primary root; e, epicotyl; f, epiblast; g, coleoptile; h, endosperm. X 30.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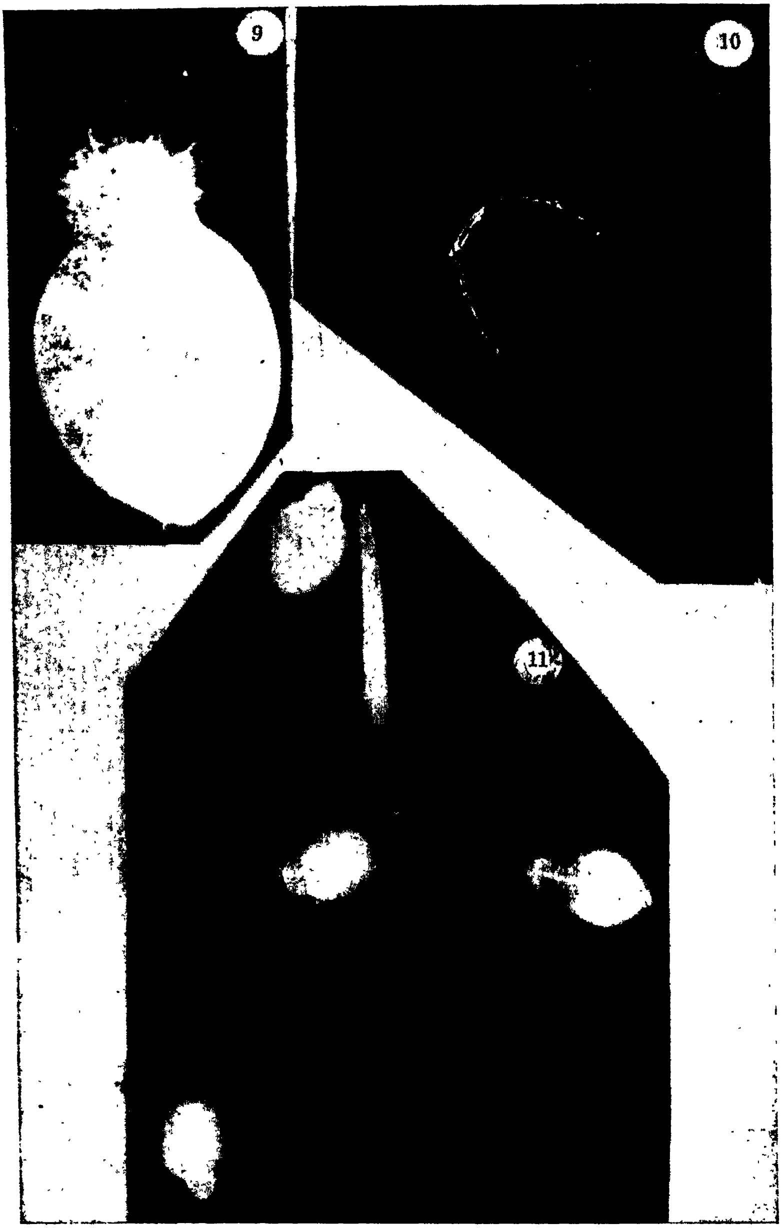

PLATE II, FIGURES 9-11

A photograph of the caryopsis showing the "roothair-like" emergences from the coleorhiza. X 27.

10. A photograph of the caryopsis showing the "flap" of the lemma. X 50.
11. A composite photograph showing seeds and seedlings in stages of germination. X 9.

indicate that this "flap" is raised by growth of the coleorhiza and not as a result of the presence of moisture. That this "flap" is loose distally can be demonstrated by inserting a needle under it and lifting it up. Membranous lodicules can be distinguished within the lemma to either side of the opening in the lemma which occurs when the "flap" is raised (Figure 4, Plate 1). There is no indication that the lodicules play any part in germination.

Further investigations show that similar "flaps" in the lemma appear in *Setaria corrugata* (Ell.) Schult, *S. geniculata* (Lam.) Beauv., *S. lutescens* (Weigel) F. F. Hubb, *S. macrostachya* H.B.K., *S. magna* Griseb., *S. setosa* (Swartz) Beauv., *S. verticillata* (L.) Beauv., *S. viridus* (L.) Beauv., *Echinochloa crus-galli* (L.) Beauv., and in *Eriochloa contracta* Hitchc.

The initial emergence of the coleorhiza can be best described as a swelling, composed of thin-walled parenchyma cells, with its surface covered with one celled "roothair-like" emergences. The primary root then pushes its way through the coleorhiza in almost any plane. This is illustrated by the series of diagrams on Plate 1, Figures 5 to 7. The epiblast is more evident after germination has commenced and its enlargment along with other embryonic structures push the lemma and palea apart. The epicotyl elongates rapidly and emerges through the opening between the palea and lemma pushing a foliage leaf through the coleoptile. The primary root elongates quickly, but not as rapidly as the epicotyl. Secondary roots arise from both the hypocotyledonary region and the primary root.

Summary

1. There has been observed a "flap-like" structure of the lemma which evidently facilitates the emergence of the coleorhiza.

2. The enlargement of the coleorhiza apparently serves to raise the "flap" of the lemma, and the "roothair-like" emergences on the coleorhiza apparently serve to increase the absorptive surface.

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Use of Fossil Soils in Kansas Pleistocene Stratigraphy

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General

Fossil soils, or buried profiles of weathering, have for many years been known to occur at various positions in the stratigraphic column. The factors controlling the development of soil profiles and the environmental implications of the several distinctive morphological types have been extensively discussed in the soils science literature and summarized in easily accessible form (U. S. Dept. Agr., 1938). Nevertheless, this tool of far reaching value to the stratigrapher has only recently been generally applied to problems of stratigraphic correlation, classification, and interpretation of the late Cenozoic deposits of the Great Plains region.

The work of Kay and Pierce (1920) attracted attention to the use of fossil soils as a means of regional correlation of glacial tills, but these workers made use of only one type of soil profile (gumbotils) developed on a till plain under conditions of poor drainage. They were not concerned with the transition of profile morphology to correlary soils developed on other materials, or under different conditions of drainage, climate, and floral cover. Leighton and MacClintock (1930) used fossil soils in a broader sense by recognizing in weathering profiles at the same stratigraphic position morphologic differences caused by different conditions of drainage or erosional history.

In Nebraska fossil soils have been used far beyond the glacial border (Lugn, 1935; Condra, Reed, and Gordon, 1947; Schultz and Stout, 1948) and one of them serves as an important stratigraphic datum over the State.

Within the past half dozen years fossil soils, or buried profiles of weathering, have been used widely as a means of correlation and classification of the Pleistocene deposits in Kansas (Frye and Fent, 1947). Fossil soils have been found at the contact of all major stratigraphic subdivisions, and two of these soils have been traced extensively over the State. Weathering profiles have been studied on Nebraska and Kansas glacial tills in the northeastern part of the State; on the Sappa member of the Meade formation; on the Loveland silt member of the Sanborn formation (Loveland soil or Sangamon soil) from the Missouri bluffs to the Colorado State line and from Nebraska to Oklahoma; and on the Peoria silt member of the Sanborn formation (Brady soil) over a region almost as great.

Fossil soils have value not only as stratigraphic markers but also as indicators of paleo-ecology. Pleistocene soils in the Great Plains region are generally well preserved. Their form and character can be compared

with those of modern soils, where the controlling environmental factors are known, and so be used as evidence of surface conditions during the intervals of weathering that produced them.

In order that ecological interpretations of a fossil profile be meaningful the topographic setting during the period of soil development must be reconstructed. A knowledge of floral cover during soil development would be most valuable to profile interpretation. Unfortunately, such data are as yet unobtainable but pollen studies of "A" horizon materials may eventually prove of value. The nature of the parent materials, subsoil drainage, and microtopography can generally be determined in the field, and comparison made with other profiles—both fossil and modern—that occupy similar situations.

Of the three orders of soil recognized in soil science (Baldwin, Kellog, and Thorp, 1938) only zonal (or normal) and intrazonal soils prove of value in Kansas Pleistocene stratigraphy. These soils exhibit distinct vertical zonation, in contrast to azonal soils, and therefore are recognizable in a sequence of clastic sediments. The vertical zonation of a soil is called its profile and is the result of all soil-forming factors affecting the regolith (Byers, Kellog, Anderson, and Thorp, 1938). In the fossil profiles studied in Kansas perhaps the most prominent and consistent feature is the removal of $CaCO_3$ from the upper layer and, except in the extreme eastern part of the State, its concentration of caliche at a deeper level. The clay content of the upper zone (or A horizon) is generally decreased by the removal downward of colloids, and clay is concentrated in a zone below the surface (the B horizon) by downward accumulation of colloids and weathering in situ of original minerals. Oxidation and other effects of weathering proceed to depths below the zone of clay accumulation and this less altered original material is referred to as the C horizon.

Conditions of poor drainage, as has been described repeatedly in soils literature, give rise to a relatively heavy clay layer and a thin zone of friable top soil. In lime-accumulating soils the depth and thickness of the caliche layer is strongly affected by subsoil drainage conditions and character of the parent material. Soils developed on gentle slopes (moderate to well-drained) generally have a deeper layer of friable top soil and a thinner layer of clay accumulation. In lime-accumulating soils the caliche zone may be relatively deep and thick and commonly consists of disseminated small caliche nodules. On excessive slopes erosion may nearly keep pace with weathering and distinct zonation of the profile may not develop; or, if erosion is less severe, a weak clay layer and relatively shallow caliche zone may result. A single fossil soil of one age, if traced through varying situations, may present as wide a range in profile morphology as the observed differences between two fossil soils of different ages. Depth of

profile, depth of leaching, thickness of the clay layer, and the nature of the caliche zone are features which can be used to determine identity of soil datum or differences in length of weathering intervals. However, great care must be exercised to compare profiles which have developed in similar parent materials under similar conditions.

A growing but somewhat precarious (Flint, 1949) use by geologists of profile morphology is the approximate dating of surface deposits by the character of the present top soil that has developed in them. It is, on the other hand, a very convenient and readily accessible means of establishing relative ages. For instance, the alluvial deposits immediately below the surface of the flood plain in many of the major valleys of Kansas are so young that a zonal profile has not yet developed, whereas low terraces above flood limit (although thought to be post-Wisconsinian in age) commonly display a thin and weakly developed but clearly recognizable zonal profile. In regions where both Peoria and Bignell loess form the surface materials at near-by similar localities the profile developed on the Peoria is generally deeper than that on the Bignell.

Comparisons of developed surface soil profiles have value for establishing relative ages when made with proper consideration of all factors controlling development. It should be borne in mind that profiles developed in similar topographic settings and under the same climatic conditions might, during the same interval of time, develop distinctly different characters if the parent materials of the two soils are different. Seemingly small differences in parent material may produce significant differences in profile morphology. Important variations in profile development may be produced by an increase of 5 or 10 per cent of initial $CaCO_3$, or a difference of 5 or 10 Meinzer units of permeability in fine-textured clastic sediments, a difference of 5 or 10 per cent initial feldspar, or several other differences that might pass virtually unnoticed in the course of ordinary field work.

Loveland Soil

The most widely recognized fossil soil in Kansas is that occurring in the top of the Loveland silt member of the Sanborn formation (Frye and Fent, 1947) and referred to as the Loveland soil (Condra, Reed, and Gordon, 1947). This soil has been described in Nebraska as the soil in the "*Citellus* zone" (Lugn, 1935). The Loveland soil not only serves as a regional stratigraphic datum but also furnishes a record of Sangamonian climate over western, central, and northeastern Kansas.

In the Missouri Valley region of Kansas and adjacent states the Loveland soil is leached of $CaCO_3$ to depths ranging up to 25 feet. At some localities a distinct zone of soil caliche is not developed and at others

caliche nodules occur in less permeable glacial till or clay below the loess.

In north-central Kansas the depth of leaching under fair to moderately good drainage conditions is commonly 3 to 5 feet, and the zone of caliche accumulation is 1 to 3 feet thick. The upper layer (A horizon) of the soil is dark brown to gray black and presents the maximum zonal color contrast observed in this soil. The horizon of clay accumulation (B horizon) is brown or reddish brown; and the C horizon, where present, is less clayey and less strongly colored. The depth of leaching diminishes to 1 to 3 feet in northwestern Kansas where the zone of caliche accumulation is thinner and less prominent, and the upper layer light brown to gray buff in color.

In southwestern Kansas the entire profile is more strongly red in color, the depth of leaching several feet, and the zone of caliche accumulation has the maximum observed development.

In all localities studied the Loveland soil is much deeper than the modern soil. Its progressive westward change in character indicates a gradual decrease in precipitation westward across the State as well as a change in floral cover. Sufficient moisture was available even in the far western area, however, to leach the upper few feet of soil and develop a recognizable caliche zone. This east to west transition closely parallels that of the modern soil but suggests a less sharp decrease in rainfall in the north-central part of the State than now exists. The contrast in Loveland soil characters from northwest to southwest, however, exceeds the contrast in modern profiles between these areas and suggests a significant climatic change in the southwest since Sangamonian time.

In areas where the Loveland soil can be contrasted with the younger Brady soil and the modern soil on Bignell silt, it is much thicker and better developed. The relative degrees of development are judged to be reflection of the intervals of time during which essentially stable conditions obtained on the soil surface and allowed operation of soil-forming processes. In the case of the Loveland, soil formation continued through much or all of Sangamonian time, whereas the Brady soil was formed during the interval from Tazewellian to Mankatoan, and modern soil, if developed on Bignell silt, during post-Mankatoan time.

Brady Soil

The youngest fossil soil in Kansas known to occur in both upland and valley situations, is developed in the upper part of the Peoria silt member of the Sanborn formation and was named the Brady soil by Schultz and Stout (1948) from a locality in southwestern Nebraska. Brady soil has been studied at many localities in west-central and northwestern Kansas where it is overlain by a few feet of Bignell silt; at a few places in north-

eastern Kansas along the Missouri Valley bluffs; and at several places in the southwestern part of the State where Brady soil is overlain by dune sand.

The maximum observed development is in the Missouri Valley bluffs in Doniphan County, where a depth of leaching of more than 15 feet occurs in favorable situations (Frye and Leonard, 1949).

At most localities in west-central and northwestern Kansas where Brady soil has been studied, conditions of poor drainage obtained on this soil surface. At some localities the Brady soil is leached several feet, displays a distinct zone of caliche accumulation, and a clay layer more than 1 foot thick.

Conclusions

Buried profiles of weathering, or fossil soils, are perhaps the most usable lithologic criterion for stratigraphic correlation and classification of the Pleistocene sediments in Kansas. The top of a buried soil is unmistakably an unconformity, and where deep well-developed profiles occur, a significant interval of nondeposition and only slight erosion is indicated. Unconformities, defined by soil profiles are judged to be desirable horizons for stratigraphic classification. Furthermore, fossil soils by comparison with modern profiles furnish a record of climate and flora during the interval of nondeposition.

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Notes on a Central American Snake, *Conophis lineatus dunni* Smith, With A Record From Honduras

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Among the Central American snakes in the collection of the Natural History Museum of Stanford University is an example of *Conophis lineatus dunni* (No. 8422) a female taken at Cofridia, Honduras, a small native village in the mountains near San Pedro Sula, May 11, 1937 by E. Ross Allen and William Piper. This record appears to be the first for the subspecies from Honduras and extends the range of the race approximately 250 miles northward from Managua, Nicaragua.

In the most recent review of the genus, Smith (1941) mentions only those specimens available to him at the time he described *C. lineatus similis* (now *C. l. dunni* see Smith 1942:395). A number of records not included by him but referred to the species *C. lineatus* by other authors have been uncovered while attempting to locate those pretaining to *C. l. dunni,* and it seems worthwhile to review them.

Dumeril, Bibron, and Dumeril (1854:938) give no further locality data for the types of *C. lineatus* than "du Mexique." It has been suggested by Smith (1941:122) that the type series may have contained one or more examples of *C. l. dunni.* Günther (1895:165) designated the specimen figured by Dumeril, Bibron, and Dumeril as the type of the species. An examination of their figure (pl. 73) indicates that the type is definitely a representative of the form now recognized as *C. l. lineatus.* The illustrated example is assigned to *C. l. lineatus* on the basis of (1) the dark stripe which passes through the eye on only one scale row anteriorly (on two rows in *C. l. dunni),* (2) the second scale row pigmented throughout the length of the body (unpigmented anteriorly in *C. l. dunni),* and (3) secondary stripes on third and eighth scale rows posteriorly (no secondary stripes in *C. l. dunni).*

Günther (1858:135) lists a specimen of *C. lineatus* in the British Museum (Natural History) from "Mexico" which might be either *C. l. lineatus* or *C. pulcher similis.* If this is the specimen listed by Boulenger (1896:123), which seems likely, it would appear from the high ventral count (171) to favor the latter species.

Salvin (1860:455) reports a specimen from Dueñas, Guatemala, which is apparently *C. p. pulcher,* the only member of the genus known from Guatemala.

Cope (1871:204) lists an example from near San José, Costa Rica. In addition to this specimen, Cope (1887:77) records a snake from

"Nicaragua" as being *C. lineatus*. Both of these specimens were considered by Smith (1941) to be *C. l. dunni*.

Bocourt (1886:643) evidently reports no new localities for the species. He figures (pl. 38, fig. 5) one of Dumeril, Bibron, and Dumeril's types which according to Smith is referable to *C. l. lineatus*.

Günther (1895:165), in addition to listing Cope's specimens cited above, records an example from Yucatan. This snake is definitely identified by Boulenger (1896:123) as being *C. l. concolor*. Günther also reports a *Conophis* from Cartago, Costa Rica. Since only *C. l. dunni* and *C. nevermanni* are known from that country, the specimen is logically one of these two forms. *C. nevermanni* appears to have a considerably higher number of ventrals (184) than the Cartago example (Boulenger 1896:123, gives the ventral count as 163). It would seem likely that had Boulenger and Günther seen a specimen of *C. nevermanni* they would have made mention of the black-bordered supralabials characteristic of this species but found in no other member of the genus. For these reasons I consider this specimen to be C. l. *dunni*. Günther's record from Vera Paz, Guatemala is based on Cope's (1868:308) description of *C. pulcher*, a species which Günther and a number of subsequent authors had placed in the synonomy of *C. lineatus*. Smith (1941:121) now believes that *C. pulcher* is a distinct form. The record from Chiapas is from Cope's (1887:77) paper and is referred to *C. pulcher similis* by Smith (1941:121).

Boulenger (1896:123) lists no new records for the species although he does record two additional specimens collected by Salvin at Dueñas, Guatemala and presumably of the same form *(C. p. pulcher)* as the 1860 record.

Dunn (1937:214) gives the following records of *C. lineatus:* Polvón, Nicaragua, and Burranca, Tivives, and Esparata, Costa Rica. These can be referred to *C. l. dunni* since only this form and *C. nevermanni,* described in Dunn's paper, are known from those countries.

Smith (1941:123) examined only three specimens of *C. l. dunni* from unrecorded localities. These were two snakes from Managua, Nicaragua (the type locality of *C. l. dunni)* and one of indefinite locale from Nicaragua.

Comparison of the Stanford example with specimens of *C. l. lineatus* (U.S. National Museum 109708, from Paso del Macho, Veracruz, Mexico) and *C. l. dunni* (U.S. National Museum 79964, from Managua, Nicaragua) and the color descriptions given by Smith (1941:122-123) shows it to be nearest *C. l. dunni,* but that it differs from that form in

several details of the pattern. It in no way approaches *C. l. concolor,* a subspecies without stripes on the body. From *C. l. lineatus* it is distinguished by having the dark dorsolateral line which passes through the eye, splitting on the neck to form two lines which pass down the third and fourth scale rows. The dark line is restricted to the fourth scale row in *C. l. lineatus.* It further differs from the typical form in having a dark stripe down the seventh (sixth posteriorly) scale row instead of the sixth as in *C. l. lineatus.* The stripes of the third and fourth scale rows fuse on the neck to produce a broad dark band several scale rows wide which continues on the head through the eye. In *C. l. lineatus* the stripe is very narrow on the nape.

The specimen does not agree with Smith's diagnosis of *C. l. dunni* in having a secondary stripe present posteriorly on the second and eighth scale rows. *C. l. dunni* also lacks pigment on the second scale row anteriorly while this row is pigmented throughout the whole length of the body in the Cofridia specimen. In both these respects it is characteristically *C. l. lineatus.*

Several conclusions are possible based on the above discussion. We could be dealing with an undescribed race of the species. The range of variation and distribution of the described forms is so poorly understood that little could be accomplished by naming a new subspecies on the basis of one specimen. A much more likely alternative is that we have here an intergrade between *C. l. lineatus* and *C. l. dunni.* The presence of characters typical of both races in the one individual lends support to this conclusion. Again, however, lack of sufficient material is a handicap and it seems best under the circumstances to regard the Stanford specimen as belonging to *C. l. dunni,* the form it most closely resembles.

Scutellation of the Hondurean example is as follows: scale rows, one head length back of head 19, at midbody 19, one head length in front of anus 17; ventrals 165; caudal 63, in two series; supralabials 8-8, the fourth and fifth in the eye; infralabials 9-8, four in contact with anterior chin shields; preoculars 1-1; postoculars 2-2; temporals 2-3 and 2-2. Teeth on the maxillary ten, of nearly equal length, followed after an interspace by two enlarged and grooved fangs.

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The Biogenetic Law for the Systematic Biologist

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Do we see during the growth of an organism the changes experienced during past time in the evolution of its species? Ever since von Baer stated the essentials of this concept and Haekel popularized them by his statement of the Biogenetic Law, that "Ontogeny recapitulates Phylogeny," there have been many evidences offered both for and against the idea. The nineteenth-century embryologists were quick to jump at the suggestion that much of past organic evolution was represented in the ontogenetic growth of a single organism (as we are all wont to grasp quickly any new idea which seems to fill some intellectual niche in the region of our minds we retain for thoughts we term appealing), and each of them offered great generalizations based on minute and restricted observations. Although in the twentieth century there has been a tendency toward a rejection of the principle, there have been a number of workers all along who have clung to the conviction that they can, in a sense, sit by and watch the evolution of a species pass in review before their eyes. These workers, however, showed that the statements of the 'law' are not universal or continuous. Does this mean that these discrepancies should rule out the existance of such a principle, or is there an explanation which will justify this discontinuity and enable us still to retain the basic validity of the 'law'?

We must first ask what the force is which directs and controls both ontogeny and phylogeny, and secondly, we must ascertain whether or not it is the same force that is common to both.

The phylogeny of an organism is its past history ("historical development"), and as such, is governed by the well-known principles of evolution. Basically, I would sum up these evolutionary principles into one phrase, that evolution is the result of the Law of Natural Selection operating on genetically differentiated constitutions. Also, any permanent control or curb on phylogeny would, of necessity, have had to have its imprint left in the heritable substance of the organism—in its germ plasm, or gene make-up.

The ontogeny, or "growth development" of an organism from the time of the fertilized egg to the mature adult, also follows to a lesser degree the evolutionary principles already set forth for phylogeny. Ontogeny is a step-wise process, with Natural Selection acting favorably towards some stages and unfavorably toward others, to their elimination, and all of these genetically controlled.

It is thus evident that both ontogeny and phylogeny are dependent

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upon the genetic make-up of the organism. Ontogeny is part of the outward manifestation of the internal make-up of a more or less static genetic construction; while phylogeny is the result of a series of steps in which either these genetic substances themselves were in some way altered, or the substrates upon which they acted were altered—creating some change in function.

We presume that all species have undergone an evolution and were not always as they are now. Also, the different changes they underwent in their phylogenetic development had to leave their imprint in the germ plasm of the species, in order that a biological heritage might exist—in order that the species itself might exist and continue. Following along with this line of reasoning, some stages in the ontogenetic development of some organism could (very possibly) recapitulate some stages of the phylogenetic development of that organism, since it is possible that a share of the imprint of its historic development still exists in its hereditary endowment—its gene constitution. Later selection effects certainly would modify this genetic make-up tremendously and the over-all picture would be anything but complete.

However, by observing the ontogenetic development of an organism, we can, with care, obtain some insight into its phylogenetic development—particularly of the more recent stages. The importance of the Biogenetic Law to the systematist lies primarily in his realization that ontogeny recapitulates speciation in the phylogeny of a specific organism, and only secondarily that the ontogeny of an organism might partially recapitulate the phylogeny of life as a whole. By a careful study of the ontogeny of an organism certain evolutionary factors, such as the determination of which characteristics are more primitive in a group, can be more closely estimated. Herein lies its value to the systematic biologist.

The Clinical Application of a Battery of Psychological Tests in the Study of Delinquents: A Case Report

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Recent advances in the theory and practice of psychological testing have extended the application of the psychological examination from tests designed primarily to determine an intelligence quotient or aptitude to tests which give data relevant to the structure and function of the "total" personality.

The manner of approaching the resultant test data has developed concomitant with the advances in the development of recent psychological tools and they have mutually supported each other. The application of these psychological tests as a means of assessing the structure and functioning of the "total" personality has, for the most part, originated in clinical settings, and these tests have been applied to the individuals who have come for psychological help, as well as several normal control groups.

Although this method has been used rather widely, it has not been used to study the personalities of that segment of the population who have become the wards of our Training Schools through conflict with the law. A more comprehensive study of this segment of our population by means of these psychological tests will aid in the development of more effective treatment techniques.

The usefulness of this method is demonstrated in the case report of Robert, a member of the Training School population.

The Case Material

Robert[1] (later known as John) was committed to the Kansas Boys Industrial School by the juvenile court of a rural county in Kansas on charges of vagrancy and transiency. The accompanying commitment form contained no social history material. There was an attached statement, however, that said it appeared that this boy was an Italian alien who had entered this county illegally.

At admission, Robert was small in stature, dark in color and appeared to be in late adolescence. During a series of three interviews given over a period of less than a week, he told the social worker in very broken English, colored with some Italian phrases and emphasized by pencil sketches, the following information. He said that he was a 16-year-old native of Eboli, Italy, a town near Salerno. He explained with pride that he had been a member of Mussolini's Youth Movement and that he was

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[1]Fictitious names are used to protect the identity of the individual.

called to fight the American invasion of Italy in 1943 in the capacity of a machine gunner at the age of 11. Robert demonstrated his activities as a machine gunner with a great display of emotion and cried as he exhibited a long scar on his forearm which he claimed was the result of a bayonet wound inflicted on him by an American soldier. He stated that both his parents were killed by American bombs and asserted his hate for the American soldiers, whom he called "cowards". After demobilization from the Italian Army, Robert stated that he obtained a job as a civilian laborer for the American Army Supply Corps and eventually became the "mascot" of the battalion. He was smuggled into the United States, he related, by sympathetic returning American soldiers but ran away in fear of being apprehended during the debarking procedures. He stated that since debarkation he had been working as a casual laborer in various sections of the United States and that he was on his way to Texas to find employment when apprehended by the police.

At the Boys Industrial School, Robert was timid, polite, and somewhat withdrawn but periodically showed signs of aggression through irritability and passive resistance. He showed a strong dislike for the Negro boys, calling them names and making violent threats. Robert spent his free time at the school drawing pictures of Italian and German soldiers and weapons. He also drew the swastika emblem on all his shirts and the walls of his room.

After Robert had been in the school approximately a week, the Immigration and Naturalization Service of the United States Department of Justice requested he be committed to their custody for deportation proceedings. However after several weeks of investigation, this service discontinued their deportation proceedings, returned the boy to the Industrial School, and reported that the subject's name was John, not Robert; that he was born on an Indian Reservation in South Dakota. Both his parents were Indian and both were deceased. The subject, John, reportedly ran away from the household of his grandmother in the fall of 1948 because of difficulties in the home and school. John was not the legal responsibility of this state, yet before definite plans for his future could be formulated, understanding of his behavior was essential. Diagnostic psychological testing was one of the approaches used in the study of John and is reported in the following discussion.

The Psychological Examination

The psychological examination of John included the following tests: 1) Wechsler-Bellevue Scale, 2) a Sorting Test, 3) Rorschach Test, 4) a Word Association Test, and 5) Thematic Apperception Test. Because of space limitations, discussion of the interpretative process will be limited.

On the Wechsler-Bellevue Scale, John achieved a total I.Q. of 85, a Verbal I.Q. of 84 and a Performance I.Q. of 89, all falling into the dull normal intelligence range. The slight inverse relationship between the verbal and performance levels indicates an unreflective person who is prone to discharge his impulses through motor activity with minimal reflective critical thought. Further examination and comparison of the weighted subtest scores shows the subject's achievements to be very irregular[2]. There were test indicators suggesting that the subject's potential for intellectual development was perhaps higher than the I.Q. scores would suggest[3]. Extremely poor achievement on several of the subtests implied severe impairment of the functions of judgment, concentration, attention, verbal concept formation and anticipation planning[4].

Item analysis of the various subtests showed that he was able to pass some difficult items while failing easy items[5]. The discrepancy between the retained and lost information appeared to be too great to be accounted for merely on the basis of anxiety-determined temporary inefficiencies but indicated a breakdown of thought processes.

The outstanding findings on the Sorting Test were: 1) many adequate sortings in respect to concept span and level, and 2) several loose conceptual sortings based on functional, concrete and syncretistic concepts. These data indicated a pathological impairment of what was once adequate concept formation to a tendency toward an over-expansiveness of concepts and conceptual concretization[6].

The Rorschach Test data contained a number of important features[7]

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[2]Weighted subtests scores: Vocabulary 9, Comprehension 7, Information 12, Digit Span 4, Arithmetic 3, Similarities 6, Picture Arrangement 5, Picture Completion 11, Block Design 9, Object Assembly 12, Digit Symbol 7.

[3]On the Information subtest, which has proven to be a relatively reliable index of an examinee's intellectual endowment (see Rapaport et al (2), Vol. I, page 130), John achieved a weighted score of 12 (an achievement in the bright normal level).

[4]Poor achievement on the Comprehension, Arithmetic, Digit Span, Similarities and Picture Arrangement subtests indicated impaired judgment, concentration, attention, verbal concept formation and anticipation and planning respectively.

[5]These findings occurred on the Information and Vocabulary subtests.

[6]Sorting Test scores: Part I: RUBBER BALL: Loose sorting, Syncretistic concept. PIPE: Adequate sorting, Functional concept. TOY PLIERS: Mildly loose sorting, Abstract concept. FORK: Narrow sorting, Syncretistic concept. CIRCLE: Adequate sorting, Abstract concept. BELL: Loose sorting, Syncretistic concept.

Part II: SMOKING MATERIAL: Functional concept. METAL: Abstract concept. ROUND: Abstract concept. TOOLS: Functional to Abstract concept. PAPER: Abstract concept. DOUBLE: Split-narrow failure. ROUND: Split-narrow Abstract concept. SILVERWARE: Functional concept. RUBBER: Abstract concept. WHITE: Syncretistic concept. TOYS: Functional concept. RECTANGLES: Syncretistic concept.

[7]Rorschach Test scores

	R: 27		EB: 2.5-2.5				
W	8	F+	10	A	15	F %	67/96
DW	2	F—	3	H	2	F+%	54/59
Dr	2	F±	2	Hd	1		
S	1	F∓	3	Obj	4	A %	56
		M+	1	At	3	Obj%	15
W%	37	FM	2+, 1—	Pl	1	H %	11
D %	52	FC	1+, 2—	Geog	1	At %	11
Dr%	1	CF	1				
		FC'	1—				

The high F% showed a strong general effort toward formal-logical reasoning and a rigid attempt to adhere to the demands of reality. The low F+%, however, indicated the weak efficiecy of these efforts and reflected a poor quality of "reality testing". Arbitrariness and severe impairment of thinking is also reflected in the DW scores, the arbitrary content assigned to Dr scores as well as in one peculiar verbalization. Stereotypy is reflected in the high A% and P% and indicates an effort to grasp the obvious and "common" in everyday situations and is suggestive of a "common sense" front.

The salient features of the Word Association Test were: 1) sporadic blocking with apparently little systematic relation between delay of reaction time and the connotation of the stimulus words, and 2) several distant reaction words. These findings showed a severe impairment of the associative process and amplified the thought disorganization indicated on the other tests.

Many of the Thematic Apperception Test stories were meagre, suggesting evasiveness and guardedness based on suspicion. The outstanding formal characteristics of the stories included several contradictions in stories, a repetition of phrases, and a disjointedness of meaning occurring as the subject introjected irrelevant details in the midst of a stream of thought. The themes of significance were those dealing with ideas of influence, hostile and anti-social activities, and gory war stories in which he identified himself with the Axis.

The presence of disorganization of thought processes in the setting of extreme anxiety, some confusion, suspicious over-cautiousness, a weak efficiency of formal-logical reasoning and accompanying poor reality testing, along with impulsive thinking and action and hostile anti-social feelings all indicated a diagnosis of acute paranoid schizophrenia in a character disorder. Hospitalization and psychiatric treatment were recommended.

Some Aspects of the Case Dynamics

Although there is an absence of relevant case material, it is thought that some inferences can be made concerning the dynamics of this subject's delusion, i.e., the unrealistic identification with the aggressor. The scant case material, observations at the Industrial School and the test data depict a case which bears many similarities to the maladjusted children described by Escalona (1); that is, John had an intense hatred toward his immediate and general environment and strong drives for aggressive retaliation. Yet it appears he felt inadequate and afraid to retaliate directly so attempted to discharge his aggressions in two major ways: 1) through disdain for a

minority group and 2) living of a phantasy of having been a member of a foreign army which inflicted heavy casualties on the American army.

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Herpetological Results of the University of Illinois Field Expedition, Spring 1949

I. INTRODUCTION, TESTUDINES, SERPENTES*

FREDERICK A. SHANNON and HOBART M. SMITH

Between April 13 and May 1, a period of 20 days, a party of five graduate students of the University of Illinois (W. Leslie Burger, I. Lester Firschein, Robert W. Reese, Frederick A. Shannon and Philip W. Smith) made a hurried circuit, collecting herpetological materials enroute, of certain roads passing through critical areas in northeastern Mexico. This material is summarized in three papers, including the present†. We have included in these summaries specimens from the United States as well as those from Mexico. All specimens, unless otherwise stated, are in the Museum of Natural History, University of Illinois, to which catalog numbers refer.

We wish to express our own gratitude and that of all members of the party for the financial support, covering all expenses of the expedition, afforded by the Museum of Natural History of the University of Illinois through the kind and generous interest of its curator, Dr. D. F. Hoffmeister.

The present paper records 26 species and subspecies, including 21 of snakes and 5 of turtles. The specimens involved number 70, of which 62 are snakes, 8 turtles. One new subspecies is represented (*Coniophanes fissidens convergens*), 6 state records (one, *Masticophis t. schotti*, for Nuevo León; two, *Ninia d. diademata* and *Thamnophis sirtalis proximus*, for Puebla; one, *Ficimia streckeri*, for Tamaulipas; and two, *Kinosternon herrerai* and *Terrapene m. mexicana*, for Veracruz), one hybrid (*Terrapene carolina triunguis* x *T. ornata*), and six species of special interest for other reasons (*Kinosternon herrerai, Pseudemys s. gaigeae, Coniophanes i. imperialis, Conophis l. lineatus, Ficimia streckeri,* and *Masticophis taeniatus schotti*).

The entire herpetological collection numbers 950 specimens, representing 76 species and subspecies. These include two new forms and numerous others of special interest. Six Mexican states (Hidalgo, Nuevo León, Puebla, San Luis Potosí, Tamaulipas, Veracruz) are represented.

The purposes of the trip were (1) to shed some light upon the existence and location of the boundary between the biotic province which

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*Contribution from the Museum of Natural History and the Department of Zoology, University of Illinois, Urbana.

†II. Amphibia, by Robert W. Reese and I. Lester Firschein, Trans. Kans. Acad. Sci. (in press); and III. Sauria, by Philip W. Smith and Leslie Burger, Trans. Kans. Acad. Sci. (in press).

includes most of Tamaulipas and that which includes the northern half of Veracruz; and (2) to investigate the poorly-known eastern edge of the escarpment north of the Jalapa area in central Veracruz. The trip was successful in adding to present knowledge especially of these areas, as well as of others; 8 of the 10 noteworthy turtles and snakes were from the indicated areas.

Detailed zoogeographic analysis of the areas on the basis of these specimens would be premature. The two regions still offer fertile fields for investigation, Obvious, however, is the fact that northern Veracruz, both on the coastal and escarpment levels, is very distinctive from the southern half of the state. Likewise obvious is a faunistic break between this area and that of most of Tamaulipas; the location of the break is not clearly evident, however, and may well not be as sharply defined faunistically as is true in many areas.

To avoid repetition of dates, the route and schedule of the party are outlined as follows:

The party left Urbana, Illinois, in the late evening of April 13. By driving steadily from then through the night of April 14, the party crossed the border at McAllen, Texas, late in the night of April 15. The men camped a few hours that night 28 miles west of China, Nuevo León, on the Monterrey highway.

On April 16 the group passed through Monterrey and stopped 4 hours at Horsetail Falls 25 miles south of Monterrey. Traveling on, the party made camp that night 8 miles northwest of Montemorelos at Arroyo de Canoas (Km. 900), Nuevo León.

April 17 the party followed the Pan-American Highway to Ciudad (del) Mante (Villa Juárez), and then turned eastward along the highway to Tampico, camping at a locality 10 miles east of Ciudad Mante, Tamaulipas.

On April 18 the group reached Tampico and continued southward into the state of Veracruz along a rather poor highway leading to Tuxpan. Camp was made 48 miles south of Tampico, at a point 1 mile north of La Laja, Veracruz.

April 19 a point 6 miles northwest of Tihuatlán near Castillo de Teayo, Veracruz, was reached.

The next day the group reached Tuxpan, and then retreated toward the southward turnoff to Nautla, camping on the main Highway 77 (Tuxpan-Pachuca) 14 miles north of Poza Rica.

On April 21 the group passed through Papantla, Veracruz, and camped 3 miles east of Gutiérrez Zamora, Veracruz, on the bank of Río Tecolutla.

On April 22 Nautla was reached, and the group continued on to a point 4 miles west of Martínez de la Torre, Veracruz, on the road from Nautla to Teziutlán, Puebla.

On April 23 the group reached its southernmost point, two miles within the borders of the state of Puebla, 7 miles south of Tlapacoyán, Veracruz. Here the party turned back on the same road, camping 11 miles east of Martínez de la Torre, Veracruz.

On April 24 the group returned past Nautla and reached Poza Rica, turning westward there on the road toward Pachuca. They camped 6 miles within the borders of the state of Puebla, 10 miles southwest of Mecatepec, Veracruz.

On April 25, a camp 9 miles northwest of Pachuca was reached. From there the group continued to a point near Pujal, where the men camped the night of April 26. The following night, after passing through Ciudad Victoria and there turning off toward Brownsville, they camped at the Río Conchos 130 miles south of Brownsville. On April 28 the group reached McAllen, Texas, and returned to Urbana by the same route followed before, arriving May 1.

Most of the localities at which collections were made are on the National Geographic Society's Map of Mexico, Central America and West Indies, December, 1939. Others are listed in the following summary. All may be located on one or the other of the following map series: (a) Mexico (F541), 1st Edition, Army Map Service, Washington, D.C., 1947, scale 1:250,000; (b) Atlas Geográfico de los Estados Unidos Mexicanos (Atlas Geográfico de la Republica Mexicana), Dirección de Geografía y Meteorologia y Hidrologia, Av. Observatorio 192, Tacubaya, D. F.

Nuevo León: Horse Tail Falls, 25 miles south of Monterrey, 2-3 miles west of Camino Nacional No. 1.
Arroyo de Canoas, 8 miles north of Montemorelos.

Tamaulipas: Gonzales, about 15 miles east of Magiscatzín, or 52 miles northwest of Tampico.
El Ciprés, 27 miles north of Ciudad Mante.
Tres Palos, 87 miles northeast of Ciudad Victoria.
Las Marias, 5 miles northeast of Tres Palos
San Fernando, 20 miles northeast of Tres Palos.

Veracruz: Naranjos (14 miles southwest of San Diego).
San Diego, 20 miles north of Tamiahua, inland 5 miles.
La Laja, 48 miles south of Tampico on Tampico-Tuxpan highway.
Poza Rica, at Río Cazones, southeast of Tihuatlán.
Gutiérrez Zamora, 7 miles west of Tecolutla.
Tlapacoyán, about 20 miles northeast of Teziutlán, Puebla.
Alamos, 16 miles north of Castillo de Teayo.
Castillo de Teayo, 6 miles northwest of Tihautlán.

Martínez de la Torre, 17 miles northeast of Tlapacoyán.
Etiopia, 2 miles south of Tecolutla.
Mecatepec, about 13 miles south of Tihuatlán.
Puebla: Villa Juárez, 15 miles northeast of Huauchinango.

Kinosternon herrerai Stejneger

This is one of the most puzzling species described from Mexico in the past 25 years. The species is extraordinarily rare despite its presumed occurrence in the well-collected environs of Mexico City (type locality "Xochimilco").

Two specimens (Nos. 4061-2) from 1 mile north of La Laja, Veracruz, however, provide evidence that the locality data accompanying the types of *herrerai* are in error. The specimens agree so perfectly with Stejneger's description that there can be little question that the association is proper. If correct, then unquestionably "Xochimilco" cannot be the original source of the types of *herrerai*. If obtained there, they must have escaped from a Veracruzian shipment. Confusion of this sort is very easily possible since turtles that have been shipped in from various localities along the eastern coast, especially central Veracruz, are widely sold in markets of Mexico City and adjacent towns. Furthermore, the donor of the specimens, Dr. Alfonso L. Herrera, is much more likely to have purchased the specimens than to have collected them himself.

The range of the species still remains in doubt, but it probably extends from about central Veracruz northward to southern Tamaulipas.

Unfortunately both specimens are females. The median plastral length is 104 mm. in each; maximum carapace width, 84 mm. in each; anterior plastral lobe 33 mm. and 35 mm., respectively, in medial length; posterior lobe 38 mm. in medial length in each; basal width of anterior lobe, 52.5 mm., 48 mm. respectively; basal width of posterior lobe 46 mm., 42.5 mm. respectively; length and width of gular 12.5 mm x 16 mm., 15 mm. x 18.5 mm. respectively; interhumeral suture, 16 mm., 15 mm.; interpectoral suture, 4.5 mm., 3.5 mm.; interabdominal suture, 29.5 mm. in each; interfemoral suture 15 mm., 13 mm.; interanal suture, 23 mm. in each; minimum length of bridge, 21 mm., 22 mm. respectively; length and width of first vertebral 26 mm x 21 mm., 27 x 18.5 mm. respectively.

Slight evidence of a median keel on posterior part of carapace, which otherwise is a smoothly rounded curve in cross section, only slightly flattened in No. 4062; 1st vertebral separated from 2nd marginal by about 2/5 length of latter; 10th and 11th marginals much higher than others, latter slightly lower than 10th; two large chin barbels (another smaller one on one side of one specimen); upper surface of head with small, closely placed, irregularly shaped, light brownish gray spots becoming

much less numerous on sides of head and on upper jaws; ventral surface of head and neck immaculate except for a few small dark streaks on lower jaws; plastron light tan, with a dark median and abdominofemoral suture in one, not in the other; dorsal surface uniform slate except sutures which in one specimen are dark.

We wish to take this opportunity to record still a third specimen of *K. herrerai*, not a part of the present collection. It is No. 4864, a juvenile male collected and presented by Mr. Ottys Sanders. It was found somewhere in northeastern Mexico between Tamazunchale and the border, along the Pan American highway. Unfortunately the precise locality data were lost.

The sex of this specimen is not fully assured, as the tail is very small and short. It does, however, have a long terminal spine and the stridulatory organs are unmistakably recognizable. The only features which do not correspond with those of the adults are (1) the smoothly rounded (not excised) posterior border of the plastron, and (2) a well-defined vertebral keel, with no evidence of lateral keels save a crinkling of the posterior edge of each costal scute at the position normally occupied by the keel in other Kinosternids. The carapace is a light tan, the posterior edges of each plate very narrowly bordered with dark brown; plastral scutes lighter, and similarly dark-edged. Median plastral length, 39 mm.; median carapace length, 54 mm.; maximum carapace width, 47 mm.; anterior plastral lobe 15 mm., posterior lobe 14.5 mm. in medial length; basal width of anterior lobe 24.5 mm., of posterior lobe 23 mm.; length of gular 6 mm., width 8 mm.; interhumeral suture 5.4 mm., interpectoral 3.4 mm., interabdominal 10 mm., interfemoral 2.5, interanal 12.5; minimum length of bridge 7 mm.; axillary and inguinal broadly in contact; median length of first vertebral 14 mm., width 135 mm.; first vertebral separated from second marginal by about 1/3 to ½ length of latter (on costal surface); 11th marginal very little higher than 10th, neither much if any higher than others; in fact, whole rear edge of carapace markedly flared in a horizontal direction; head with a fine spotting or reticulation of light brown on a lighter background.

Terrapene carolina triunguis (Agassiz)

One specimen (No. 4603) was taken at Hearne, Robertson County, Texas, another (No. 4065) at Buffalo, Leon County, Texas.

Terrapene carolina triunguis (Agassiz)

X

Terrapene ornata (Agassiz)

A single specimen (No. 4064) is from Coldwater, Wayne County, Missouri (2 miles south of Madison County line). It is an adult female measuring 126 mm. in median plastral length.

The plastron is marked exactly as in typical *ornata*; the beak is strongly developed; the head is large; the plastron is widest across the abdominals; there is a short bridge. In these four characters the specimen is typical of *ornata.*

On the other hand, the head is unicolor brown above, light spotted on jaws; there is a distinct vertebral keel; the carapace is domed; there are three toes; the axillary is absent or greatly reduced in size; and the plastron completely closes the carapace aperture. In these characters the specimen resembles *triunguis.*

Some of these characters are from Cahn (1937:99), and others are of common knowledge. As represented in the present specimen, they are sufficiently well divided between those of the two species that the probability of the specimen's identity as a hybrid seems incontrovertible.

Terrapene mexicana mexicana (Gray)

One specimen (No. 4058) is from 1 mile north of La Laja, Veracruz, and the other (No. 4059) from 2 miles southwest of Tuxpan, Veracruz. Both are 3-toed females, the larger (No. 4058) an enormous specimen measuring 165 mm. in plastral length. The maximum recorded appears to be 188 mm. (Müller, 1936:101).

These specimens appear to be the first recorded from the state of Veracruz.

Pseudemys scripta elegans (Wied)

A single specimen (No. 4060) was found 1 mile south of Arkadelphia, Clark County, Arkansas. It is an immature female measuring 94 mm. in medial plastral length.

Pseudemys scripta gaigeae Hartweg

A single female (No. 4094) measuring 94 mm. in medial plastral length was found crushed on the highway in the outskirts of McAllen, Hidalgo County, Texas. The head pattern is typical, including an oval temporal spot measuring 3 mm. x 6 mm. Distinct ocelli are present on the posterior marginals, and the plastral markings approach a linear pattern on the rear half. The specimen probably represents an intergrade between *gaigeae* and *elegans*; in the absence of other evidence it may be referred to *gaigeae*, to the characters of which it most closely conforms. Typical *gaigeae* is to be expected nearer the Rio Grande.

Leptotyphlops myopicus myopicus (Garman)

Two specimens were obtained, one (No. 3793) at Horsetail Falls, 25 miles south of Monterrey, Nuevo León, the other (No. 3794) 5 miles NE of Huauchinango, Puebla. Each has supraoculars, two preocular labials,

scales in 14 rows of which the 7 dorsal are pigmented, 10 scale rows around base of tail. Respectively, they have 218 and 220 dorsals. No. 3794 is the second specimen recorded from the state of Puebla.

Haldea striatula Linne

Four specimens were taken, all in Texas, as follows: three (Nos. 3826-8) from the banks of the Colorado River, Austin, Travis County, and one (No. 3829) 7 miles south of Marshall, Harrison County. The ventrals are 126, 135, 132, 120 respectively; caudals 42 male, 33 female, 46 male, 46 female; scale rows 17-17-17 in all except No. 3827, with 17-17-16; supralabials 5-5, infralabials 6-6, oculars 1-1, in all; total length 232 mm., 235 mm., 228 mm., 192 mm., tail length 46 mm., 48 mm., 41 mm.

Ninia diademata diademata Baird and Girard

A single specimen (No. 3822) is from 6-7 miles northeast of Teziutlán, Puebla. It is typical, with 19-19-19 scale rows, 140 ventrals, 80 caudals (female), 6-6 supralabials, 6-6 infralabials, 1-2 oculars, 1-2 temporals, total length 353 mm., tail 110 mm. The pattern is typical.

This species has not previously been recorded from this state. The present specimen shows no approach toward the characters of *plorator*, which is to be expected at higher altitudes in Puebla.

Natrix erythrogaster flavigaster Conant

A single female (No. 3840) was found DOR near Buffalo, Leon County, Texas. It has 23 scale rows at middle of body, 15 in front of anus; ventrals 145, caudals 64; total length 740 mm., tail 159 mm. Very faint evidence of dorsal blotches is discernible under fluid. The abdomen has a faint yellowish cast anteriorly but the ventrals are rather extensively pigmented along their anterior edges.

Actually this specimen represents an intergrading population between *transversa* and *flavigaster*, with however a preponderance of affinity with the latter.

Natrix rhombifera blanchardi Clay

Two young specimens (Nos. 3841-2) were found 11 miles east of Martínez de la Torre, Veracruz. They have 25-23-19, 25-25-23-19 scale rows respectively; 147, 142 ventrals; 83 (male), 68 (female) caudals; 8-8, 8-8 supralabials; 11-11, 10-10 infralabials; 1-1, 2-2 preoculars; 3-3, 3-3 postoculars; total length 592 mm., 513 mm.; tail 154 mm., 119 mm. The characteristic *rhombifera* dorsal pattern of small rhombs is clearly evident (although adults of this race are unicolor above), but the semilunar spots on the venter are dim, as is typical of *blanchardi*.

Thamnophis marcianus marcianus (Baird and Girard)

Three specimens are available, one (No. 3814) from 2.8 miles south of McAllen, Hidalgo County, Texas, and two (Nos. 3812-3) 15 miles north of Ciudad Mante (Villa Juárez), Tamaulipas. The scale rows are 21-21-18, 21-21-17, 20-21-17 respectively, ventrals, 154, 155, 146; caudals 61+ male, 80 male, 37+ female; preoculars 1-1, 2-2, 1-1; postoculars 3-3, supralabials 8-8, infralabials 10-10 in all; total length 510 mm., 621 mm., 887 mm.; tail 110+ mm., 155 mm., 90 mm.

The presence of 2 preoculars in one specimen is of special interest as an anomaly; Mittleman (1949:240) recorded the occurrence of more than one preocular in only 3 other specimens of 225 examined.

The specimens fall well within the expected range of variation of this race as opposed to the more western *nigrolateris* as diagnosed by Mittleman (*op. cit.*).

Thamnophis sirtalis proximus (Say)

Seventeen specimens are in the collection, as follows. *Texas:* 1½ miles west of McAllen, Hidalgo County (No. 3811); 7 miles south of Marshall, Harrison County (No. 3795). *Tamaulipas:* 10 miles east of Ciudad Mante (Villa Juárez) (Nos. 3804-3806); 15 miles north of Ciudad Mante (Nos. 3807-9). *Veracruz:* 4 miles west of Martínez de la Torre (Nos. 3796-8); 1-2 miles west of Tecolutla (Nos. 3799-3803). *Puebla:* 6 miles southwest of the Veracruz-Puebla state line, 10 miles southwest of Mecatepec, Veracruz (No. 3810).

This subspecies has not previously been recorded from the state of Puebla, although the southern race, *chalceus,* is known from that state.

The scale rows are uniformly 19-19-17, the supralabials 8-8, the infralabials 10-10, the preoculars 1-1, postoculars 3-3 (except one with 3-4). In the order listed above, the ventrals and caudals are respectively: 163, 49+ male; 162, 9+ male; 155, 91 female; 163, 102 male; 154, 89 female; 153, 42+ female; 156, 89 female 168, 100+ male; 155, 91 female; 153, 92 female; 154, 56+ female; 160, 44+ male; 153, 56+ male; 159, 87 female; 155, 51+ female; 156, 94 female; 157, 15+ female.

Five of the six males are typical *proximus,* having either a ventral count (in the absence of a complete tail) or a ventral and caudal count exceeding the maximum in *chalceus*; the one exception, No. 3800, has 5 fewer ventrals, at 153, than the minimum previously recorded in Mexican *proximus,* but a figure in the middle of the range variation in *chalceus.*

The eleven females, however, agree more closely with *chalceus.* The total ventral and caudal counts of the seven with complete tails vary between 243 and 250 (243, one; 245, two; 246, three, 250, one); 255 is

the minimum previously recorded for Mexican *proximus,* 254 the maximum for *chalceus.* The ventral counts of the 11 females vary between 153 and 159 (153, two; 154, two; 155, three; 156, two; 157, one; 159, one); the previously recorded range for Mexican *proximus* is 155 to 169, for *chalceus* 142 to 159.

Examined individually, the southern specimens (all except those from Texas) should obviously be considered as intergrades between *proximus* and *chalceus.* The single Puebla specimen, a female with 157 ventrals, tail incomplete, is as near *proximus* as the others; in the absence of a series we regard it as the same as the others represented by larger series from northern Veracruz, at about the same latitude.

Ficimia streckeri Taylor

A single specimen (No. 3830) was taken on Camino Nacional No. 107, between Las Marias and Jiménez, Tamaulipas. This provides a basis for the first record of the species from the state of Tamaulipas, although the species was to have been expected. It is a male with 17-17-17 scale rows, 127 ventrals, 34 caudals, 7-7 supralabials and infralabials, 1-1 postoculars and preoculars, total length 320 mm., tail length 55 mm. The dorsal blotches are not band-like, but are narrow, not extending beyond about the 7th scale row on each side, and number 50 from snout to vent. This deviation from the banded pattern probably indicates reduction of the spots and approach toward a unicolor pattern. It is not known, and now seems unlikely, that even the southernmost specimens become completely unicolor as in *F. olivacea,* yet southern specimens do show a marked reduction in pattern. In spite of approach in this respect to the southern form *olivacea,* the northern form *streckeri* does possess throughout its range certain very marked differences in proportion that prevent assumption of intergradation, as indicated by Taylor (1949-192). This reverses Smith's (1944:139) original conclusion.

Southern *F. streckeri* from Xilitla, Tuxpan and Jacala probably represent a race distinct from that recorded to the north in the states of Tamaulipas, Nuevo León and Texas. In the latter (1) the pattern is uniformly band-like; (2) the scale counts are reduced (ventrals 127-144 male, 143-150 female, caudals 34-40 male, 30-34 female); and (3) the postoculars are 1-1 with only one exception. In the southern race the scale counts are higher (ventrals 144-154 male, 149-157 female; caudals 34-38 male, 29-35 female); the pattern uniformly reduced, blotch-like or spotty, sometimes nearly obsolete; and the postoculars are frequently 2-2 (7 in 14).

All three of these distinctive features parallel the characters in *olivacea,* so the implication of intergradation is indeed very obvious.

Nevertheless the body, head and eye proportions are markedly different and show no evidence of clinal variation. In the absence of sufficient comparative material of *olivacea* we refrain, however, from definitely concluding at the present time that the southern specimens of *streckeri* represent a distinct race.

Drymobius margaritiferus margaritiferus (Schlegel)

Two specimens (Nos. 3823-4) were taken, one (No. 3823) 14 miles north of Villagran, Tamaulipas, the other (3824) 6 miles east of Gutiérrez Zamora, Veracruz. The scale rows are 15-17-15, 17-17-15 respectively; ventrals 151, 149; caudals 105, 84+; supralabials 9-9, 8-9; infralabials 9-10, 10-10; preoculars 1-1, postoculars 2-2 in each; total length 1040 mm., 915+ mm.; tail 365 mm., 274 mm.+. The pattern is typical, each dorsal scale with a central yellow spot and blue anterior edges.

Coluber constricter flaviventris Say

Two males were obtained; one (No. 3837) is from 2 miles northwest of Henderson, Rusk County, Texas; the other (No. 3838) is from 2 miles north of Desloge, St. Francois County, Missouri. The scale rows are 17-17-17, 17-17-15 respectively; ventrals 170, 169; supralabials 8-8, 8-7; infralabials 8-8, 8-8; preoculars 2-2, 2-2; postoculars 2-2, 2-3; total length 810 mm., 736 mm.; tail length 223 mm., 205 mm.

Masticophis flagellum testaceus (Say)

Two specimens were obtained, one (No. 3835) 16 miles northeast of Buffalo, Leon County, Texas, the other (No. 3834) 8.4 miles north of Villagran, Tamaulipas. In each the dorsals are in 19-17-13 rows, the ventrals 191, the supralabials 8-8, the preoculars 2-2. Respectively the postoculars are 2-3, 2-2; caudals 95 female, 104 (+ 1 or 2) male; total length 610 mm., 1210 mm.; tail length 154 mm., 315 (+ 3 — 4) mm.

The young specimen from Texas has an extensively pigmented venter anteriorly as in *f. flagellum*, but narrow dorsal crossbands as in *f. testaceus*. The specimen appears to be an intergrade between the two races, and to represent perhaps a greater probability of population affinity with *testaceus* than with *flagellum*.

Masticophis taeniatus ruthveni Ortenburger

A single male (No. 3831) is from El Ciprés, 27 miles north of Ciudad Mante, Tamaulipas. It has 15-15-13 scale rows, 195 ventrals, 129+ caudals, 8-8 supralabials, 11-11 infralabials, 2-2 oculars, total length 1375 mm., tail 45+.

Two heads (Nos. 3832-3) were taken from DOR specimens found on the road 19 miles south of Encino, in Hidalgo County, Texas. No stripes

are evident, except faint ones on the lateral scale rows, as is typical of *ruthveni*. The shape of the frontal—slender and elongate—is infallible evidence that these specimens do not represent the genus *Coluber*, the adult heads of the local race of which otherwise closely resemble those of *ruthveni*. One specimen has 10 infralabials (rare in *Coluber*).

Masticophis taeniatus schotti Baird and Girard

A fine specimen (No. 3836) was secured at Horsetail Falls, 25 miles south of Monterrey, Nuevo León. It is a young male measuring 710 mm. in total length, the tail 243 mm. The scale rows are 15-15-13, ventrals 197, caudals 151, supralabials 8-8, infralabials 10-11, oculars 2-2. A well defined stripe involves the adjacent edges of rows 3 and 4, and another, rather well defined, involves the adjacent edges of the ventrals and first row of dorsals. The sides of the belly are rather strongly pigmented; anterolateral edges of each dorsal scale light; edges of dorsal head scales not light.

This specimen, representing a race hitherto recorded in Mexico only from extreme northern Coahuila, is of special interest, as it not only extends the range of the form into Nuevo León, but also indicates that the complex of forms of *taeniatus* on the northern part of the Mexican plateau is even more involved than hitherto suspected. Four forms are now known from the plateau and its immediate environs: *ornatus, schotti, australis* and *ruthveni*. Pattern seemingly excludes this specimen from reference to *ruthveni,* which does not have striped young except in intergrading areas; *australis* is excluded on the basis of absence in it of a lateral abdominal light stripe and of pigment at sides of ventrals; *ornatus* is much different, lacking light anterolateral edges on the dorsal scales, and having a broader dorsolateral light stripe involving the 5th scale row. The specimen agrees perfectly, on the other hand, with *schotti,* the range of which must be conceived as extending finger-like at least to the Monterrey area, separating there the range of *ruthveni* to the east from that of *ornatus* (northern) and perhaps in part that of *australis* (southern) to the west.

The specimen also presents the possibility that the Alvarez intergrades discussed by Smith (1943:450) represent only *ruthveni* and *schotti.* Many more specimens will be needed to settle the status of populations at the eastern edge of the plateau.

Elaphe laeta laeta (Baird and Girard)

A single male (No. 3839) is from 29 miles northeast of Ciudad Victoria, Tamaulipas. It has 25-27-19 scale rows, 85 caudals, 8-8 supralabials, 14-14 infralabials, 1-2 oculars, 2-3 temporals, 1003 mm. total length, 205 mm. tail length. Another live specimen was taken from between McAllen and the Rio Grande, Hidalgo County, Texas.

Pituophis catenifer sayi (Schlegel)

A single specimen (No. 3825) was found 16 miles south of Encino, Hidalgo County, Texas. It is a typical adult female with 29-35-23 scale rows, 232 ventrals, 47 caudals, 8-9 supralabials, 13-13 infralabials, 1-2 preoculars, 3-4 postoculars, 61 dorsal blotches on body, 1190 mm. total length, 131 mm. tail length.

Conophis lineatus lineatus (Duméril, Bibron and Duméril)

A fine adult male (No. 3847) furnishes the basis for the third record of the species from a definite locality. It is from 2 miles south of Tecolutla (at Etiopa), Veracruz. Scale rows 19-19-15, ventrals 163, caudals 72, supralabials 7-8, infralabials 9-9, oculars 2-2, temporals 2-2, total length 592 mm., tail 127 mm. The pattern agrees perfectly with the description given by Smith (1941:122), except for an error in the latter which states that there is "a narrow dark stripe along sixth scale row, continuous throughout length of body," while as a matter of fact the stripe referred to is situated on the 6th scale row only posteriorly; anteriorly and at the middle it involves the 7th scale row.

Painful bites on the hands of Mr. Firschein and Mr. Burger resulted in slight swelling, and a feeling of numbness which persisted for some time.

Coniophanes fissidens convergens subsp. nov.

Type. University of Illinois Museum of Natural History No. 3821, collected 6 miles northwest of Tihuatlán, near Castillo de Teayo, Veracruz, April 20, 1949, by W. Leslie Burger.

Diagnosis. A race of *Coniophanes fissidens* related to *C. f. proterops* and similar to *C. f. dispersus;* apparently: dorsal scale rows 19; males with supraanal ridges; supralabials 7; ventrals 121, caudals 80, ventrals-minus-caudals 41 in a single male; median border of dorsolateral light stripe well defined on tail, poorly defined on rear of body; dorsolateral light stripe disappearing about two head lengths posterior to head; spots on belly very small, scattered.

Description of type. Portion of rostral visible from above one half length of median internasal suture; prefrontals much larger than internasals, their median suture 2 2/3 length of that of internasals; frontal a little less than 1½ times as long as broad, its length 5/4 its distance from tip of snout, which in turn is about equal to its distance from posterior (median) edge of parietal; sides of frontal somewhat convergent posteriorly; nasal completely divided; loreal small, slightly smaller than lower postoculars; 1-1 preoculars; 2-2 postoculars; temporals 1-2, the upper secondary twice as long as lower secondary; supralabials 7-7.

Anterior chinshields ¾ length of and a little wider than posterior

chinshields; latter separated from each other except for their anterior third; infralabials 9-9, the first ones in contact medially between chinshields and mental, the anterior five in contact with chinshields (two with the posterior, four with the anterior); head scales with a sprinkling of fine pustules absent on body.

Dorsal scales in 19-19-15 rows; ventrals 121 (male); caudals 80; anal divided; total length 474 mm., tail 157 mm.

Dorsal pattern very poorly defined, the whole surface nearly uniform, dull, light brown; sides slightly darker than back, with a sharply defined dark line marking the boundary between the two zones along the lower edge of the fifth (anteriorly) and upper edge of the fourth (posteriorly) scale rows; dorsum slightly lighter adjacent to this dark line than elsewhere, but no dorsolateral light stripes evident except (1) on nape, where it is whitish, well defined, occupying less than one scale row anteriorly at its point of margin at angle of jaws, and nearly all of two scale rows posteriorly at about 3 head lengths back of the head where it disappears completely, and (2) on extreme posterior part of body and on tail, where the stripe, little lighter than on body, has a well defined, black median edge. A narrow white line along sides of head extending from lower margin of orbit through the angle of the jaws, and bordered above by a dark line merging above with the ground color; one or two large, light bordered dark spots on each of the anterior 5 supralabials; latter otherwise stippled on a light (whitish) background; chin and throat rather closely stippled; numerous small black flecks on belly and tail, somewhat more numerous laterally.

Remarks. No subspecies concept can be particularly well founded upon a single specimen, but we believe the concept based upon this individual has a high probability of approximate accuracy and of validity since (1) the characters inferred are similar to those identifying other races of this species, and (2) since the present specimen comes from *well within* a faunistically distinctive area north of central Veracruz. Particularly interesting, and of some importance in consideration of the present race as distinct, is the high degree of parallelism between it, the northernmost east coast form, and *C. f. dispersus,* the northernmost west coast form. The assumption is made that the closest relative of *C. f. convergens,* the adjacent form, as indicated not only by its geographically adjacent position but also by certain characteristics in pattern and scutellation, is *C. f. proterops.*

C. f. convergens differs from *C. f. proterops* chiefly in having higher caudal and lower ventral counts. It differs from *C. f. dispersus* chiefly in having fewer supralabials and more sharply defined dorsolateral light lines on tail and extreme posterior part of body.

The type was found under a pile of debris at the base of a tree at the edge of a small stream.

Coniophanes imperialis imperialis (Kennicott)

A fine series of 6 specimens was secured. One (No. 3820) is from 1½ miles west of McAllen, Hidalgo County, Texas; one (No. 3816) from Poza Rica, Veracruz; one (No. 3815) from 3 km. southwest of Tihuatlán, Veracruz; and three (Nos. 3817-19) from 1-2 miles west of Tecolutla, Veracruz. No. 3816 had been killed on the road when found, and does not show all features of scutellation.

The median dorsal dark stripe is broad in all specimens, involving half or more of the paravertebral scale rows as is typical in this subspecies. In this, perhaps the most useful feature distinguishing *i. clavatus* and *i. imperialis*, there is little indication of mergence with the southern race. In scale counts, however, the southernmost specimens approach *i. clavatus*, which averages fewer ventrals and more subcaudals than *i. imperialis*. Most extraordinary is No. 3819 with 90 subcaudals, 13 in excess of Bailey's (1939:39) range limit. The total range as now known, however, closely parallels that of *i. clavatus* with a spread of 20 in each. Such an extensive range of variation does not occur in the compact race *i. copei* (with a spread of only 9) but may be expected in such wide ranging and variable races as *i. imperialis* and *i. clavatus*. A peculiar variation in the Tecolutla series is the occurrence in all specimens of a large dark spot on each of the anterior 5 or 6 supralabials.

Another distinctive feature of the same series is the occurrence in two specimens of an isolated nape spot split from the dorsolateral light stripes, whereas in the third specimen the nape spot is narrowly fused with the dorsolateral light stripes. This variation has not been recorded previously in *i. imperialis*, although it is known in *i. clavatus* from scattered localities. Bailey (1939:37) records a similar variation in a specimen from Toxtlacuaya which otherwise agreed well with *i. imperialis*. Future collections may indicate the existence of a recognizably different race in northern Veracruz characterized by an isolated nape spot, spotted labials and perhaps a high caudal count. Central Veracruz specimens differ in having a narrow dorsal stripe and no isolated nape spot, whereas Campeche specimens have the isolated nape spot in addition to the narrow dorsal stripe.

The postocular light line is relatively short, not reaching the end of the parietals, in all except No. 3820 (Texas). In this the stripe reaches beyond the end of the parietals on one side, even on the other. This specimen is distinct from the others in lacking a distinct dark line along the second scale row on nape. Likewise the Texan specimen is unique among the series in showing very little differentiation of the lateral dark

zone into an upper dark and lower light area. In all 5 of the southern specimens the lower edge of the dark area on the sides of the head is continuous posteriorly on the nape, for a distance equal to one or two head lengths, with a well defined black line sharply separating the darker and lighter areas. In northern *i. imperialis* the dark and light areas blend gradually into each other except for a very short distance on the nape less than the head length.

Variation in *C. i. imperialis*

3815	male	19-19-15	126	74	8-8	8-8	1-1	2-2	365	121
3816	male	?-19-15	128	....	8-?	?-?	1-?	2-?	......	......
3817	male	19-19-15	124	62+	8-8	8-8	1-1	2-2	380	......
3818	male	19-19-15	126	77	8-8	8-8	1-1	2-2	323	110
3819	male	19-19-15	123	90	8-7	8-8	1-1	2-2	370	140
3820	male	19-19-15	132	79	8-8	8-8	1-1	2-2	423	139

Leptodeira maculata (Hallowell)

Four specimens were obtained: No. 3843 was taken 15 miles north of Ciudad Mante, Tamaulipas; No. 3844, one mile north of La Laja, Veracruz; and Nos. 3845-6, Poza Rica, Veracruz. No. 3846 was found dead on the road, flattened so greatly that scale counts cannot accurately be made, but the pattern is sufficiently clear to permit positive identification.

Respectively these specimens (excluding No. 3846) vary as follows: Scale rows, 21-23-17, 23-21-23-17, 21-23-17; ventrals 170, 167, 173; caudals 60+ female, 68 male, 71 male; preoculars and postoculars 2-2 throughout; supralabials 8-8, infralabials 10-10, temporals 1-2-3 throughout; total length 615+ mm., 565 mm., 421 mm.; tail 115+ mm., 120 mm., 92 mm.; dorsal blotches on body 24, 25, 22.

The absence in the collection of the other species of *Leptodeira (annulata)* known to occur commonly in the area traversed suggests a seasonal activity for that species.

Bothrops atrox asper (Garman)

A single specimen, still alive at the present writing, was obtained at night crossing a trail on a densely wooded hillside 3 kilometers southwest of Tihuatlán, Veracruz.

Crotalus atrox Baird and Girard

Two specimens were obtained intact: No. 3849, 11 miles south of Encino, Brooks County, Texas, and No. 3850, 6 miles southwest of Jiménez (at Santander) Tamaulipas. Two others were found DOR, one (No. 4476) 2 miles north of McAllen, the other (No. 4477) 6 miles north of McAllen; Hidalgo County, Texas. The heads only of the latter two were retained. A specimen still alive at the present writing was taken 7 miles southwest of Jiménez, Tamaulipas.

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A Study of Longevity in McPherson County

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This paper is a continuation of a study started by the late Dr. H. J. Harnly of McPherson College some twenty years ago at which time he recorded all marked graves of McPherson County, and from these records tabulated the life span of individuals in ten-year periods until the year 1920. Our study begins with 1920 and continues until the year 1940. Two records have been tabulated, those obtained in the McPherson City cemetery and those from the other cemeteries of the County.

The sciences of medicine, bacteriology, immunology, together with the advancements of the mechanical arts, and the accompanying development of techniques of family limitation, have lowered mortality considerably, thus increasing, in this county, the individual life expectancy by about 30.5 years since 1880.

In 1940 the expectancy of life at birth for the total population of the United States was close to 65 years. The expectancy of life in McPherson City, as shown by our studies in the same year, was approximately 64; in the remaining part of McPherson County life expectancy during the same time was only about 58 years.

The following table shows the increase in the life span of persons living in McPherson County since the early settlement, as recorded on the tombstones.

Life Expectancy at Birth in McPherson County

Life Span	Before 1880	1880-1889	1890-1899	1900-1909	1910-1919	1920-1929	1930-1939
	Years by 10 year periods						
1. Average life span							
a. McPherson City	24.0	29.0	42.0	50.0	54.0	58.4	63.61
b. Remainder of McPherson Co.	23.0	24.5	34.5	42.0	53.0	57.7	57.6
2. Per cent of deaths under 21 yrs.							
a. McPherson City	56.0	51.0	37.0	17.0	13.0	8.3	5.72
b. Remainder of McPherson Co.	52.5	55.0	52.0	30.0	17.5	12.6	8.41
3. Per cent of deaths under 5 yrs.							
a. McPherson City	36.0	33.0	24.0	11.0	7.0	3.9	2.0
b. Remainder of McPherson Co.	38.6	42.0	22.0	18.0	11.3	5.74	2.8
4. Per cent of deaths under 1 yr. (Entire County)	33.3	24.5	16.1	12.6	7.3	1.7	.33

The trends shown by Dr. Harnly have continued to date and are in keeping with the general trends throughout the United States. We especially call attention to the percentage of deaths under five years of age; this splendid record accounts for much of the advancement in life span.

The Quality of Riley County Rural School Drinking Water

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The only sanitary supervision over private rural water supplies in America is that exercised by the private owner, hence, for practical purposes is nonexistant. As a result, it is well known that when judged by the criteria commonly applied to municipal supplies American rural waters are low in sanitary quality. There are, however, certain extenuating circumstances which mitigate somewhat the public health significance of this situation.

Farmsteads as a rule, are more or less isolated and a given water supply usually is used by only one family. Also, there is evidence to indicate that most of the pollution is of nonhuman origin and even should pollution be of human origin, it usually is derived primarily from the single family making use of the water. So long as the few individuals of the family remain healthy no serious consequences are likely to result from consumption of the water. Finally, typhoid fever, formerly the enteric scourge of rural America, has been largely eliminated.

The semi-public rural school water supplies, however, are in a somewhat different category in that the number of individuals possibly affected by a single supply is multiplied by the number of families represented by the pupils enrolled; or by a much larger group where the school serves as a center of community activity. The quality of such waters thus becomes a much more significant public health problem. In view of the number of epidemics of enteric infections that have been recorded as arising from the consumption of rural school waters, it is a problem worthy of more consideration than it receives in most communities.

Provision is made in Kansas for limited supervision of rural school waters in that a sanitary survey of water sources may be made at any time by county health officers in those counties provided with a county health unit, and the State Board of Health laboratories will examine any samples of water submitted to them by local county health officers. However, even where provision is made for such examinations they are seldom made more frequently than once annually, and rarely can the tests be carried out as specified in "Standard Methods for the Examination of Water and Sewage."(1) Failure to adhere to the procedure outlined in "Standard Methods" is no fault of the laboratories involved, but lies in the inability, in most cases, to deliver rural water samples to the laboratory within the specified six hours following collection.

Transactions of the Kansas Academy of Science, Vol. 52, No. 4, 1949.

Contribution No. 254, Department of Bacteriology, Kansas State College. Abstract of a thesis presented by the senior writer in partial fulfillment for the degree Master of Science.

This local survey of rural school water was undertaken (a) to gain information which might be of value in advising local school boards on such matters, (b) to accumulate additional information on the influence of delayed examinations upon the quantitative findings of coli-aerogenes bacteria in rural waters, and (c) to accumulate data relative to the types of coli-aerogenes in local rural waters.

There were in operation in Riley County during the 1948-1949 school year 34 schools or school systems involving separate water supplies. Five of these were located in towns with public water systems and while they were tested, and in all cases found satisfactory, they can not be regarded as rural insofar as the water sources are concerned. Thus 29 rural school water supplies were studied.

Methods

Samples of water were collected in the fall and again in the spring after frost was out of the soil. For one reason or another five of the school-yard sources had been abandoned prior to this study and during the school year 1948-1949 water was brought to the schools by the teachers from farmstead sources. With one exception these farm sources, as well as the water in the school-room container, were examined. In a few other instances water for drinking purposes was kept inside the building and a few examinations of such waters were made.

The collection and preliminary handling of water samples, preparation of media, cultural procedures, incubation, isolation and identification of coli-aerogenes, etc. were all carried out as prescribed in "Standard Methods" unless otherwise indicated.

Efforts were made to isolate coli-aerogenes from every 10 ml. and every 1.0 and 0.1 ml. portion which gave eiter a positive or doubtful presumptive test. In many instances a 50 ml. portion of water was introduced into a fermentation bottle at the well. If these gave gas formation and the standard tests carried out upon reaching the laboratory did not, as sometimes happened, efforts were made to isolate coli-aerogenes from them.

The presence of spore-bearing anaerobes was tested for as follows: 10 ml. of sterile, skimmed milk was inoculated with 10 ml. of the water in question. To this was added a one-half inch layer of a sterile sealing mixture composed of paraffin and vaseline, after which the tubes were heated at 80° C. for 20 minutes, cooled and incubated at 37° C. for five days. Coagulation of the milk accompanied by vigorous gas formation and followed by digestion of the curd was recorded as positive for spore-bearing anaerobes. The quantity of water used in this test was small; however, previous observations had indicated relatively large numbers of such

organisms in local rural waters and the results of this survey substantiated these observations.

A summary of the data collected is presented in Table I. It is realized that the number of samples of water from each source examined is too small to warrant any far-reaching conclusions. The data are adequate, however, to indicate certain trends relative to the conditions of rural school waters in Riley County.

Table I. Bacterial content of Riley County rural school waters.

School	Standard portions examined	Standard portions containing Coli-aerogenes	Standard portions containing *E. coli*	Plate count Low	Plate count High	Samples containing spore-bearing anaerobes	Quality as judged by overall findings
Hunters Island	15	9	2	2000	2600	1 of 3	Poor
Ashland Bottoms	25*	0	0	5	100	2 of 5	Excellent
McDowell Creek	10	0	0	16	100	0 of 2	Excellent
College Hill	20	2	0	0	2900	0 of 4	Good
Strong	20	0	0	2	24	0 of 4	Excellent
Keats Grade	20	4	0	2	140	0 of 4	Good
Keats High	15	3	0	0	7	2 of 3	Good
Magic	20	4	0	1	55	0 of 4	Questionable
Myersdale	20	0	0	0	6	3 of 4	Excellent
Bala	20	3	0	0	23	3 of 4	Good
Laurel Hill (School-room)	15	5	1	6	4200	1 of 3	Poor
Pleasant Hill (Farm well)	20	0	0	0	4	1 of 4	Excellent
Pleasant Hill (School-room)	20	6	0	31	5000+	1 of 4	Poor
Alert	25*	0	0	7	170	3 of 5	Excellent
Grand View	25*	1	0	1	1500	2 of 5	Good
Stockdale	20	5	0	18	96	4 of 4	Questionable
Winkler	25*	11	1	0	100	4 of 5	Questionable
May Day (Farm well)	20	1	0	1	550	2 of 4	Good
May Day (School-room)	15	6	2	375	5000+	3 of 3	Poor
Star	25*	3	0	3	90	2 of 5	Good
Columbus	20	0	0	0	19	3 of 4	Excellent
Ober (Farm well)	10	4	3	44	60	1 of 2	Questionable
Ober (School-room)	20	5	4	70	5000+	3 of 4	Poor
Peach Grove	20	0	0	5	85	4 of 4	Excellent
Swede Creek	15	1	0	0	6	0 of 3	Good
Cleaburne Grade	20*	3	0	6	150	3 of 4	Good
Cleaburne High	15	5	0	2	38	2 of 3	Questionable
Rose Hill (Farm well)	5	1	0	180		1 of 1	Excellent
Rose Hill (School-room)	15	3	2	3	2800	3 of 3	Poor
Tabor Valley	20	4	0	190	2700	4 of 4	Poor
Oak Grove	20	1	1	0	1000	2 of 4	Poor
Zeandale	20	7	0	21	700	3 of 4	Poor
Sherman	25*	1	0	0	49	3 of 5	Excellent

*One sample taken from container in school-room.

The primary objective in the routine bacteriologic examination of drinking waters is to evaluate their quality in terms of potability. Any interpretation of bacteriologic data collected in water analysis, such as presented in Table I, must be more or less arbitrary. In grouping the waters in the various quality categories as indicated in Table I the following system was employed.

Waters which met "Public Health Service Drinking Water Standards"[2] and also gave consistently low plate counts are classed as "excellent". Waters from which coli-aerogenes were recovered from not more than 20% of the standard portions, did not contain *E. coli,* and consistently gave low plate counts; or which met Public Health Service requirements with respect to coli-aerogenes but occasionally gave a high plate count, are designated as "good".

Those waters in which coli-aerogenes was present in more than 20% but not more than 40% of the standard portions and from which *E. coli* was not isolated, yet consistently gave low counts are graded as of "questionable" quality. While all samples from which *E. coli* was isolated, which contained coli-aerogenes in over 40% of the standard portions, or which consistently gave high plate counts are graded as definitely "poor".

On these bases 10 sources are classed as excellent, 9 as good, 3 as questionable, and 6 as poor in quality. It should be pointed out, however, that in all five instances where water was brought from farms to the school the water available for the pupils to drink was of poor quality even though the water from the four of these wells examined was good or excellent.

The fact that two-thirds of the 28 sources graded good or excellent would indicate that it is relatively easy to maintain satisfactory sources of water for rural schools. The poor quality of waters transported from farm wells to the school room is undoubtedly due to unsatisfactory handling of the water after it was drawn from the well. The lack of available water on the school premises for thorough washing of the container could readily account for this unsatisfactory situation. These limited data indicate that neglect on the part of local school boards to look after the cleaning and repair of local school water sources, thus necessitating the bringing in of water by the teacher, imposes an inexcusable health hazard upon the school children.

Two or three of the unsatisfactory sources can be explained as due to poor location of the wells. The available evidence in the case of most of the others suggests intermittent contamination, probably resulting from faulty installation of the pump and/or inadequate removal of waste water. Such situations could be easily remedied.

While no special significance was attached to the presence or absence of spore-bearing anaerobes in evaluating the quality of these rural school waters, it is of interest to note that such organisms were present in unusually large numbers. They were detected in a 10 ml. portion of one or more samples of water from 22 of the 28 sources examined, including 8 of the 10 sources graded as excellent. Of the 123 samples examined 66 contained spore-bearing anaerobes in a 10 ml. portion. This condition might be interpreted as indicative of intermittent surface contamination.

Table II. Classification of coli-aerogenes isolated from rural school waters.

	Number of coli-aerogenes cultures isolated	Identification of cultures					
		E. coli	*Aero. aerogenes*	*Aero. cloacae*	Intermediate I	Intermediate II	Unclassified
From water source	106	9	18	4	53	9	13
From container water	35	11	16	1	5	1	1
Total	141	20	34	5	58	10	14

In Table II is presented a differential classification of the coli-aerogenes cultures isolated from rural school waters.

Intermediate type I (50%) and *Aerobacter aerogenes* (17%) were found to be the most prevalent types of coli-aerogenes present in rural school water sources. The dominant types gaining entrance after the waters are drawn from the well are *Aerobacter aerogenes* (43%) and *Escherichia coli* (31%).

The data relative to the influence of delayed testing upon the quantitative findings of coli-aerogenes in rural waters is presented in Table III.

Table III. The effect of delayed analysis upon the most probable number (m.p.n.) of coli-aerogenes in waters.

Sample No.	Initial m.p.n. of coli-aerogenes per 100 ml. waters	M.p.n. of coli-aerogenes per 100 ml. water after 24 hours at room temperature
1a	>240.0	5.0
1b	38.0	8.8
3a	2.2	0.0
7a	5.0	0.0
10a	38.0	0.0
11	38.0	8.8
11a	15.0	8.8
12c	38.0	8.8
17a	240.0	5.0
17b	240.0	0.0
17c	>240.0	2.2
18	240.0	0.0
19	240.0	>240.0
19a	240.0	15.0
19b	>240.0	>240.0
20	8.8	2.2
22	>240.0	15.0
22a	5.0	2.2
22b	>240.0	0.0
26	>240.0	5.0
26b	240.0	2.2
27	7.6	2.2
27a	240.0	5.0
27b	2.2	0.0
29b	7.6	8.8
30a	21.0	5.0

The initial tests were started immediately upon reaching the laboratory, however, the distance of the points of collection from the laboratory and the large number of samples collected on a given field trip, necessitated an elapse time of one to six hours between the collection of a water sample and its introduction into laboratory media. During this time the samples were held at a temperature below 10° C. Following the initial inoculation the samples were placed at room temperature and at the end of an additional 24 hours a second presumptive test for coli-aerogenes was carried out on all samples which gave an initial positive presumptive test. The data in Table III are, therefor based upon positive presumptive tests rather than completed tests. Since coli-aerogenes were isolated from 25 of the 26 initial tests it is evident that the decrease in most probable number of lactose fermenters was due largely to decreases in coli-aerogenes. The most probable numbers are taken from the "Most Probable Numbers" table in Standard Methods.

Of 26 samples initially giving a positive presumptive test and held at room temperature for 24 hours, 7 failed to give a positive test and 16 showed a marked decrease in the most probable number of gas forming organisms present. In a number of instances inoculations made at the well proved positive, whereas inoculations made upon reaching the laboratory one to six hours later were negative.

Other investigators have reported data similar to that here presented. Caldwell and Parr[3] were able to recover coli-aerogenes from only 56.4% and *E. coli* from only 62.9% of a large number of miscellaneous initially positive water samples after they had been held at laboratory temperatures for 24 to 30 hours. In the case of a smaller group of contaminated wells the corresponding values were 45.5% and 41.9%, respectively.

These authors also compared the recovery of coli-aerogenes and *E. coli* from the same series of water samples following inoculations made at the well and from iced samples immediately upon reaching the laboratory one to seven and one-half hours later. This comparison revealed a decrease of 20.8% and 38.6% in the number of samples positive for coli-aerogenes and *E. coli,* respectively, for the larger group of wells, and a corresponding decrease of 28.6% and 44.6% for the contaminated wells during the short interval of one to seven and one-half hours. Similar reductions in lactose fermenters have been reported by Webster and Raghavachari[4] for Madras waters under comparable conditions.

Summary

Nineteen of the 28 rural school water sources of Riley County were found to be satisfactory. Most of the other sources probably could be made satisfactory with the installation of slight improvements. Neglecting the repair of local school water sources, thereby requiring the teacher to bring water in from other sources, imposes an unnecessary health hazard upon pupils, even though the temporary source may be satisfactory. Such a practice is to be condemned.

Spore-bearing anaerobes were unusually prevalent in these rural school waters.

The dominant type of coli-aerogenes found in Riley County rural school water sources was intermediate type I. The dominant types gaining entrance after waters were drawn from the wells were *Aerobacter aerogenes* and *Escherichia coli.*

Evidence is submitted indicating that tests for coli-aerogenes carried out on samples of water 24 hours after collection may give little indication of the coli-aerogenes content of the water at its source.

Literature Cited

(1) Standard Methods for the Examination of Water and Sewage; Ninth Edition. 1946. American Public Health Association, New York.

(2) Public Health Service Drinking Water Standards 1946. Public Health Reports 61: No. 11; 371-384. 1946.

(3) CALDWELL, ELFREDA L., and PARR, LELAND W. Present Status of Handling Water Samples. Am. J. Public Health 23: 467-472. 1933.

(4) WEBSTER, W. J., and RAGHAVACHARI, T. N. S. Comparative Results of the Bacteriological Examination of Madras Waters at the Source and After Transportation. Ind. J. Med. Research 23: 57-68. 1935.

Kansas Academy of Science—Report of the Treasurer

April 27, 1948 to April 14, 1949

Receipts

Balance in checking account, April 27, 1948	$ 442.88	
Annual dues for membership	1,321.00	
Life members' payments for Transactions	18.00	
Sale of Transactions	24.36	
Sale of Winter Twigs	9.23	
Reprints	584.56	
State of Kansas	1,000.00	
Exchange Rights	1,250.00	
A.A.A.S.	115.00	
Academy Handbooks	1.80	
Transactions Index	.35	
Percentage Table	.60	
Interest on Investments	66.99	
U.S. Savings Bond ((D395746C)—final distribution	500.00	
		$5,334.77

Disbursements

Secretary—postage, stenographic help, supplies		$ 86.67	
Treasurer—bond premium, bank box rent, annual report		14.72	
Managing Editor—supplies		77.65	
Executive Council Members Mileage—October, 1948		51.00	
Wichita East Science Club—engraving cups		5.20	
Ralph Rogers—Junior Academy expenses		7.85	
Junior Academy Awards		25.25	
First National Bank, Hays, Kansas—for returned checks		3.00	
First National Bank, Hays, Kansas—for five $100.00 Savings Bonds		500.00	
Edwin R. Walker—expenses to annual meeting		28.00	
Frank C. Gates—expenses to Academy Conference, Washington, D. C.		56.89	
Theodore Sperry—Botany Section expenses		.90	
Research Awards		195.54	
Workman Printing Co.—programs, letterheads, envelopes, announcements		114.30	
Elliott Addressing Machine Co.—stencils		4.81	
The Outlook—paper and envelopes		109.70	
Editorial Board			
The World Company—No. 25977	$705.17		
No. 26366	595.15		
No. 26919	651.60		
No. 105	689.87		
Capper Engraving Co.—No. 10116	156.31		
No. 10769	109.04		
No. 11432	190.92		
No. 12106	98.55	3,196.61	
		$4,478.09	
Balance in checking account, April 14, 1949		856.68	
			$5,334.77

Supplementary Statement

Outstanding checks Nos. 9, 58, 99	$ 9.82
Accounts Receivable—Reprints	229.16

Awards Account

Amount in fund April 27, 1948			$ 200.90	
Received during the year:				
Reagan Bond		$ 25.00		
A.A.A.S.		115.00	140.00	
Total			$ 340.90	
Awarded—to L. J. Gier	$ 25.00			
to Charles Hess	25.00			
to Milford W. Johnston	30.00			
to Herman D. Smith	35.00			
Amount Paid—to L. J. Gier		$ 25.00		
to Charles Hess		25.00		
to Leon Lungstrom		49.76		
to Herman D. Smith		22.00		
to Austin Williams		73.78	195.54	
Balance				$ 145.36

Bank balance April 14, 1949	$ 866.50	
Outstanding checks	9.82	
Actual balance		$ 856.68

STANDLEE V. DALTON, *Treasurer*

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Original articles are entered under the name of their fields (Archeology, Chemistry, etc.), under the name of the author (given in italics) and under the title, usually abbreviated (and also in italics).

Date of issue.	Date of issue.	Date of issue.

MGIPC—S5—38 AR/54—7-7-54—7,000.